P23703.A06

OIPE JC174 FEB 1 0 2005 PATENT & TRADEMARK OFFICE

IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hiroshi NOMURA

Group Art Unit : 2851

Serial No : 10/646,812

Examiner : Arthur A. SMITH

Filed : August 25, 2003

For : LENS BARREL HAVING A MOVABLE OPTICAL ELEMENT SUPPORT FRAME

SUBMISSION OF VERIFIED TRANSLATION OF JAPANESE PRIORITY DOCUMENT

U.S. Patent and Trademark Office
Customer Window, Mail Stop Amendment
Randolph Building
401 Dulany Street
Alexandria , VA 22314

Sir :

Further to the Amendment and Response filed on January 31, 2005, Applicant submits herewith a verified translation of Japanese Patent Application No. 2003-25444 (upon which priority of the present U.S. Patent Application is based), which was filed in Japan on February 3, 2003, thereby perfecting priority of the present application under 35 U.S.C. § 119 and removing U.S. Patent Publication No. 2003/00156832 A1 as a reference.

Should there by any questions regarding this paper or the present application, the Examiner is respectfully requested to contact the undersigned at the below-listed telephone number.

Respectfully submitted,
Hiroshi NOMURA

William S. **Boshnick**
Reg. No. **44,550**

Will S. Boshnick

Bruce H. Bernstein
Reg. No. 29,027

February 10, 2005

GREENBLUM & BERNSTEIN, P.L.C.
1950 Roland Clarke Place
Reston, VA 20191
(703) 716-1191

DECLARATION

I, Hikaru MORIOKA, 1-17, Uchiya 3-chome, Minami-ku, Saitama-shi, Saitama, Japan, do hereby declare that I am familiar with the English and Japanese Languages and that I believe the annexed is an accurate translation of the certified copy of the Japanese Patent Application No.2003-25444, filed on February 3, 2003.

This 15th day of November , 2004

Hikaru Morioka

Hikaru MORIOKA

JAPANESE PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: February 3, 2003

Application Number: JP2003-25444

Applicant(s): PENTAX Corporation

May 30, 2003

Commissioner,

Japan Patent Office

Shinichiro OTA

Certification No.2003-3040744

【TITLE OF THE DOCUMENT】 APPLICATION FOR PATENT

【REFERENCE NUMBER】 P5043

【ADDRESSEE】 Commissioner, Patent Office

【INTERNATIONAL PATENT CLASSIFICATION】 G02B 7/00

【INVENTOR】

【Address】 c/o PENTAX Corporation
36-9, Maenocho 2-chome, Itabashi-ku, Tokyo

【Name】 Hiroshi NOMURA

【APPLICANT】

【Identification Number】 000000527

【Name】 PENTAX Corporation

【ATTORNEY】

【Identification Number】 100083286

【Patent Attorney】

【Name】 Kunio MIURA

【ATTORNEY】

【Identification Number】 100120204

【Patent Attorney】

【Name】 Iwao HIRAYAMA

【INDICATION OF FEE】

【Advance Payment Registration Number】 001971

【Official Fee】 21000

【ATTACHED DOCUMENTS】

【Name of Document】 Specification 1

【Name of Document】 Drawing

1

【Name of Document】 Abstract

1

【Comprehensive Power of Attorney Number】 9704590

【Comprehensive Power of Attorney Number】 0301076

【NEED FOR PROOF】 Necessary

【TITLE OF THE DOCUMENT】 SPECIFICATION

【TITLE OF THE INVENTION】 LENS BARREL

【CLAIMS】

1. A lens barrel comprising:

a support ring;

a movable lens group positioned inside said support ring, and moving forward and rearward in an optical axis direction; and

a rearmost lens group positioned behind said movable lens group, and movable in said optical axis direction,

wherein an arm portion is formed on a lens frame of said rearmost lens group to project in a radial direction of said lens frame, and

wherein said lens barrel further comprises a guide shaft positioned outside a ring portion of said support ring to guide said rearmost lens group in said optical axis direction via said arm portion.

2. A lens barrel including: a support ring; and a front optical element, a middle optical element, and a rear optical element which are positioned on an optical axis in a ready-to-photograph state of said lens barrel, at least said front optical element and said middle optical element being movable independently in said optical axis direction,

wherein a support frame of said middle lens group comprises a bowl-shaped portion which projects forward, and an arm portion which projects in a radial direction of said support frame from a rear end of said bowl-shaped portion,

wherein said lens barrel further comprises a guide shaft positioned outside a ring portion of said support ring to guide said middle lens group in said optical axis direction via said arm portion, and

wherein, in a retracted state of the lens barrel, said rear optical element is in said bowl-shaped portion of said support frame while said front optical element is positioned in space formed by an outside of said bowl-shaped portion and front of said arm portion.

3. The lens barrel according to claim 2, wherein said arm portion comprises a pair of arm portions positioned to substantially face each other on opposite sides of said optical axis, and

wherein one of said pair of guide shafts which corresponds to one of said pair of arm portions is positioned radially outside said front optical element which is in said retracted state from said optical axis.

4. The lens barrel according to claim 2 or 3, wherein each of said front optical element and said middle optical element is a movable lens group, and

wherein said rearmost optical element is an image pick-up device.

5. The lens barrel according to claim any one of the preceding claims 2 through 4, wherein said front optical element and a frontmost optical element which is positioned in front of said front optical element in said ready-to-photograph state are moved along said optical axis while changing space between said front optical element and said frontmost optical element to perform a zooming operation.

6. The lens barrel according to claim 5, wherein said frontmost optical element is positioned side by side with said middle optical element when said lens barrel is in said retracted state.

7. The lens barrel according to any one of the preceding claims 2 through 6, wherein said support frame of said middle lens group is moved in said optical axis direction to perform a focusing operation.

8. The lens barrel according to any one of the preceding claims 2 through 7, wherein said rear optical element is a fixed optical element.

【DETAILED DESCRIPTION OF THE INVENTION】

【0001】

【Technical Field】

The present invention relates to the structure of

an autofocus lens frame of a lens barrel.

【0002】

【Prior Art and Problems Thereof】

In a conventional lens barrel, the structure guiding an AF lens frame is disposed radially inside a lens barrel.

【0003】

However, such a guiding structure tends to become an obstacle to a reduction of the length of the lens barrel if the lens barrel is designed so that the length thereof becomes smaller in an non-operating state of the lens barrel than in an operating state of the lens barrel, and thus makes it difficult to utilize the camera's internal space for accommodating elements of the camera with efficiency.

【0004】

【Related Patent Documents】

Japanese Patent Application H10-161001

Japanese Patent Application H11-231201

【0005】

【Objective of the Invention】

An object of the present invention is to provide a lens barrel having a structure guiding an AF lens frame, wherein the structure does not become an obstacle to a reduction of the length of the lens barrel to thereby make

it possible to improve the utilization of the camera's internal space for accommodating elements of the camera, and wherein the space having a sufficient length for guiding the AF lens frame can be secured.

【0006】

【Summary of the Invention】

To overcome the aforementioned problem, the lens barrel according to an aspect of the present invention is characterized in that the lens barrel includes: a support ring; a movable lens group positioned inside the support ring, and moving forward and rearward in an optical axis direction; and a rearmost lens group positioned behind the movable lens group, and movable in the optical axis direction, wherein an arm portion is formed on a lens frame of the rearmost lens group to project in a radial direction of the lens frame, and wherein the lens barrel further comprises a guide shaft positioned outside a ring portion of the support ring to guide the rearmost lens group in the optical axis direction via the arm portion.

【0007】

A lens barrel according to an aspect of the present invention includes: a support ring; and a front optical element, a middle optical element, and a rear optical element which are positioned on an optical axis in a

ready-to-photograph state of the lens barrel, at least the front optical element and the middle optical element being movable independently in the optical axis direction, wherein a support frame of the middle lens group comprises a bowl-shaped portion which projects forward, and an arm portion which projects in a radial direction of the support frame from a rear end of the bowl-shaped portion, wherein the lens barrel further comprises a guide shaft positioned outside a ring portion of the support ring to guide the middle lens group in the optical axis direction via the arm portion, and wherein, in a retracted state of the lens barrel, the rear optical element is in the bowl-shaped portion of the support frame while the front optical element can be positioned in space formed by an outside of the bowl-shaped portion and front of the arm portion.

【0008】

Preferably, the arm portion comprises a pair of arm portions positioned to substantially face each other on opposite sides of the optical axis, wherein one of the pair of guide shafts which corresponds to one of the pair of arm portions is positioned radially outside the front optical element which is in the retracted state from the optical axis.

【0009】

Each of the front optical element and the middle optical element can be a movable lens group, while the rearmost optical element can be an image pick-up device.

【0010】

The front optical element and a frontmost optical element which is positioned in front of the front optical element in the ready-to-photograph state can be moved along the optical axis while changing space between the front optical element and the frontmost optical element to perform a zooming operation. The support frame of the middle lens group can be moved in the optical axis direction to perform a focusing operation. On the other hand, the rear optical element is preferably a fixed optical element.

【0011】

Preferably, the frontmost optical element is positioned side by side with the middle optical element when the lens barrel is in the retracted state.

【0012】

【Embodiment】

An embodiment according to the present invention will be discussed below in detail with reference to the accompanying drawings.

Firstly, the overall structure of an embodiment of a zoom lens 71 according to the present invention will

be hereinafter described below with reference to Figures 1 through 19. This embodiment of the zoom lens 71 is incorporated in a digital camera 70, and is provided with a photographing optical system consisting of a first lens group (frontmost optical element) LG1, a shutter S, an adjustable diaphragm A, a second lens group (front optical element) LG2, a third lens group (middle optical element) LG3, a low-pass filter (optical filter) LG4, and a solid-state image pick-up device (CCD; rear optical element) 60. "Z1" shown in the drawings designates the optical axis of the photographing optical system. The photographing optical axis Z1 is parallel to a lens barrel axis Z0 of the zoom lens 71, and is decentered with respect to the lens barrel axis Z0. In the following descriptions, the term "optical axis direction" means a direction parallel to the photographing optical axis Z1 unless there is a different explanatory note on the expression.

【0013】

As shown in Figures 6 and 7, the camera 70 is provided in the camera body 72 thereof with a stationary barrel 22 fixed to the camera body 72, and a CCD holder 21 fixed to a rear portion of the stationary barrel 22. The CCD image sensor 60 is mounted to the CCD holder 21 to be held thereby via a CCD base plate 62. The low-pass

filter LG4 is held by the CCD holder 21 to be positioned in front of the CCD image sensor 60 via a filter holder 73 and a sealing member 61.

【0014】

The zoom lens 71 is provided in the stationary barrel 22 with an AF lens frame (third lens frame which supports and holds the third lens group LG3/ support frame) 51 which is guided linearly in the optical axis direction without rotating about the photographing optical axis Z1. Specifically, the zoom lens 71 is provided with a pair of AF guide shafts 52 and 53 which extend parallel to the photographing optical axis Z1 to guide the AF lens frame 51 in the optical axis direction without rotating the AF lens frame 51 about the photographing optical axis Z1. Front and rear ends of each guide shaft of the pair of AF guide shafts 52 and 53 are fixed to the stationary barrel 22 and the CCD holder 21, respectively. The pair of AF guide shafts 52 and 53 are respectively fitted into a pair of guide holes so that the AF lens frame 51 is slidable on the pair of AF guide shafts 52 and 53. In this particular embodiment, the AF guide shaft 52 serves as a main guide shaft, while the AF guide shaft 53 serves as a member for preventing the AF lens frame 51 from rotating. An AF motor 160 having a rotary drive shaft is threaded to serves as

a feed screw shaft, and this rotary drive shaft is screwed through a screw hole formed on an AF nut 54 fixed to the AF lens frame 51. Due to this structure, rotating the rotary drive shaft forward and rearward causes the AF lens frame 51 to move forward and rearward in the optical axis direction by engagement of the rotary drive shaft (feed screw shaft) with the AF nut 54. The AF lens frame 51 is biased forward in the optical axis direction by an AF-frame biasing spring 55.

【0015】

As shown in Figure 5, a zoom motor 150 and a reduction gear train box 74 are mounted on the stationary barrel 22. The reduction gear train box 74 contains a reduction gear train for transferring rotation of the zoom motor 150 to a zoom gear 28. The zoom gear 28 is pivoted to the stationary barrel 22 by a zoom gear shaft 29 which extends parallel to the photographing optical axis Z1. Rotations of the zoom motor 150 and the AF motor 160 are controlled by a control circuit of the digital camera via a lens-drive-control FPC (flexible printed circuit) board 75 which is positioned on an outer peripheral surface of the stationary barrel 22.

【0016】

The stationary barrel 22 is provided on an inner peripheral surface thereof with a female helicoid 22a,

a set of three linear guide grooves 22b, a set of three lead grooves 22c, and a set of three rotational sliding grooves 22d. The set of three linear guide grooves 22b extend parallel to the photographing optical axis Z1. The set of three lead grooves 22c extend parallel to the female helicoid 22a. The set of three rotational sliding grooves 22d are formed in the vicinity of a front end of the inner peripheral surface of the stationary barrel 22 to extend along a circumference of the stationary barrel 22 to communicate the front ends of the set of three lead grooves 22c, respectively. The female helicoid 22a is not formed on that specific front area of the stationary barrel 22 on which the set of three rotational sliding grooves 22d are formed (see Figure 8).

【0017】

A helicoid ring 18 is provided on an outer peripheral surface thereof with a male helicoid 18a and a set of three rotational sliding projections 18b. The male helicoid 18a is engaged with the female helicoid 22a, and the set of three rotational sliding projections 18b are engaged in the set of three lead grooves 22c or the set of three rotational sliding grooves 22d, respectively (see Figures 4 and 9). The helicoid ring 18 is provided on threads of the male helicoid 18a with a spur gear portion 18c which is in mesh with the zoom

gear 28. Therefore, when a rotation of the zoom gear 28 is transferred to the spur gear portion 18c, the helicoid ring 18 moves forward or rearward in the optical axis direction while rotating within a predetermined range in which the female helicoid 22a remains in mesh with the male helicoid 18a. A forward movement of the helicoid ring 18 beyond a predetermined point causes the spur gear portion 18c to be disengaged from the zoom gear 28 so that the helicoid ring 18 rotates about the lens barrel axis Z0 without moving in the optical axis direction relative to the zoom gear 28 by engagement of the set of three rotational sliding projections 18b with the set of three rotational sliding grooves 22d. A circumferential space between two adjacent threads of the female helicoid 22a between which one of the three lead grooves 22c is positioned is greater than that between another two adjacent threads of the female helicoid 22a between which none of the three lead grooves 22c is positioned. The male helicoid 18a includes three wide threads 18a-W and twelve narrow threads. The three wide threads 18a-W are positioned behind the three rotational sliding projections 18b in the optical axis direction, respectively. The circumferential width of each of the three wide threads 18a-W is greater than that of each of the twelve narrow threads so that each of the three wide

threads 18a-W can be positioned in the associated two adjacent threads of the female helicoid 22a between which one of the three lead grooves 22c is positioned (see Figures 8 and 9). The stationary barrel 22 is provided with a stop-member insertion hole 22e which radially penetrates one rotational sliding groove 22d and an outer peripheral surface of the stationary barrel 22. A barrel stop member 26 for preventing the helicoid ring 18 from rotating beyond a photographing range thereof is detachably attached to the stop-member insertion hole 22e.

【0018】

The helicoid ring 18 is provided, on an inner front peripheral surface thereof at three different circumferential positions on the helicoid ring 18, with three rotation transfer recesses 18d (see Figures 4 and 10), while the third external barrel 15 is provided, at corresponding three different circumferential positions on the third external barrel 15, with three pairs of rotation transfer projections 15a (see Figures 4 and 11) which project rearward from the rear end of the third external barrel 15 to be inserted into the three rotation transfer recesses 18d from the front thereof, respectively. The three pairs of rotation transfer projections 15a and the three rotation transfer recesses

18d are movable relative to each other in a direction of the lens barrel axis Z0, and are not rotatable relative to each other about the lens barrel axis Z0. Namely, the helicoid ring 18 and the third external barrel 15 rotate in one piece. The helicoid ring 18 is provided on the three rotational sliding projections 18b with a set of three engaging recesses 18e which are formed on an inner peripheral surface of the helicoid ring 18. The third external barrel 15 is provided with a set of three engaging projections 15b which are engaged in the set of three engaging recesses 18e, respectively. The set of three engaging projections 15b, which are respectively engaged in the set of three engaging recesses 18e, are also engaged in the set of three rotational sliding grooves 22d at a time, respectively, when the set of three rotational sliding projections 18b are engaged in the set of three rotational sliding grooves 22d (see an upper half of the zoom lens in Figure 6).

【0019】

The zoom lens 70 is provided between the third external barrel 15 and the helicoid ring 18 with three separating-direction biasing springs 25 which bias the third external barrel 15 and the helicoid ring 18 in opposite directions away from each other in the optical axis direction. The rear ends of the three

separating-direction biasing springs 25 are respectively inserted into three spring insertion recesses 18f which are formed on the front end of the helicoid ring 18, while the front ends of the three separating-direction biasing springs 25 are respectively in pressing contact with three spring-engaging recesses 15c formed at the rear end of the third external barrel 15. Therefore, the set of three engaging projections 15b of the third external barrel 15 are respectively pressed against front surfaces in the set of three rotational sliding grooves 22d by the spring force of the three separating-direction biasing springs 25, while the set of three rotational sliding projections 18b of the helicoid ring 18 are respectively pressed against rotation guide surfaces in the set of three rotational sliding grooves 22d by the spring force of the three separating-direction biasing springs 25. This removes backlash of the third external barrel 15 and the helicoid ring 18 with respect to the stationary barrel 22.

【0020】

The third external barrel 15 is provided on an inner peripheral surface thereof with a plurality of relative rotation guide projections 15d which are formed at different circumferential positions on the third

external barrel 15, a circumferential groove 15e which extends in a circumferential direction about the lens barrel axis Z0, and a set of three rotation transfer grooves 15f which extend parallel to the lens barrel axis Z0 (see Figures 4 and 11). The circumferential positions of the three rotation transfer grooves 15f are formed to correspond to those of the three pairs of rotation transfer projections 15a, respectively. The rear end of each rotation transfer groove 15f is open at the rear end of the third external barrel 15. The helicoid ring 18 is provided on an inner peripheral surface thereof with a circumferential groove 18g which extends in a circumferential direction about the lens barrel axis Z0 (see Figures 4 and 10). The zoom lens is provided inside the third external barrel 15 and the helicoid ring 18 with a first linear guide ring 14. The first linear guide ring 14 is provided on an outer peripheral surface thereof with a set of three linear guide projections 14a, a first plurality of relative rotation guide projections 14b, a second plurality of relative rotation guide projections 14c, and a circumferential groove 14d in this order from rear to front of the first linear guide ring 14 in the optical axis direction (see Figures 4 and 12). The set of three linear guide projections 14a project radially outwards.

The first plurality of relative rotation guide projections 14b project radially outwards at different circumferential positions on the first linear guide ring 14, and the second plurality of relative rotation guide projections 14c project at different circumferential positions on the first linear guide ring 14. The circumferential groove 14d is an annular groove with its center on the lens barrel axis Z0. The first linear guide ring 14 is guided in the optical axis direction with respect to the stationary barrel 22 by engagement of the set of three linear guide projections 14a with the set of three linear guide grooves 22b, respectively. The third external barrel 15 is coupled to the first linear guide ring 14 to be rotatable about the lens barrel axis Z0 relative to the first linear guide ring 14 by both the engagement of the second plurality of relative rotation guide projections 14c with the circumferential groove 15e and the engagement of the plurality of relative rotation guide projections 15d with the circumferential groove 14d. The second plurality of relative rotation guide projections 14c and the circumferential groove 15e are engaged with each other to be slightly movable relative to each other in the optical axis direction. Likewise, the plurality of relative rotation guide projections 15d and the circumferential groove 14d are

engaged with each other to be slightly movable relative to each other in the optical axis direction. The helicoid ring 18 is coupled to the first linear guide ring 14 to be rotatable about the lens barrel axis Z0 relative to the first linear guide ring 14 by engagement of the first plurality of relative rotation guide projections 14b with the circumferential groove 18g. The first plurality of relative rotation guide projections 14b and the circumferential groove 18g are engaged with each other to be slightly movable relative to each other in the optical axis direction.

【0021】

The first linear guide ring 14 is provided with a set of three guide slots 14e which radially penetrate the first linear guide ring 14. As shown in Figure 12, each guide slot 14e includes a front circumferential slot portion 14e-1, a rear circumferential slot portion 14e-2, and a lead slot portion 14e-3 which connects the front circumferential slot portion 14e-1 with the rear circumferential slot portion 14e-2. The front circumferential slot portion 14e-1 and the rear circumferential slot portion 14e-2 extend parallel to each other in a circumferential direction of the first linear guide ring 14. The lead slot portion 14e-3 extends parallel to the threads of the female helicoid

22a. A set of three roller followers 32 fixed to an outer peripheral surface of a cam ring (rotating ring) 11 at different circumferential positions thereon are engaged in the set of three guide lots 14e, respectively. Each roller follower 32 is fixed to the cam ring 11 by roller set screws 32a. The set of three roller followers 32 are further engaged in the set of three rotation transfer grooves 15f through the set of three guide lots 14e, respectively. A set of three roller pressing protrusions 17a protrude rearward from a roller-biasing spring 17 to be engaged in front portions of the set of three rotation transfer grooves 15f, respectively (see Figure 11). The set of three roller pressing protrusions 17a press the set of three roller followers 32 rearward to remove backlash between the set of three roller followers 32 and the set of three guide lots 14e when the set of three roller followers 32 are engaged in the front circumferential slot portions 14e-1 of the set of three guide lots 14e, respectively.

【0022】

Advancing operations of movable elements of the zoom lens 71 from the stationary barrel 22 to the cam ring 11 will be understood with reference to the above described structure of the digital camera 70. Namely, rotating the zoom gear 28 in a lens barrel advancing

direction by the zoom motor 150 causes the helicoid ring 18 to move forward while rotating about the lens barrel axis Z0 due to engagement of the female helicoid 22a with the male helicoid 18a. This rotation of the helicoid ring 18 causes the third external barrel 15 to move forward together with the helicoid ring 18 while rotating about the lens barrel axis Z0 together with the helicoid ring 18, and further causes the first linear guide ring 14 to move forward together with the helicoid ring 18 and the third external barrel 15 because each of the helicoid ring 18 and the third external barrel 15 is coupled to the first linear guide ring 14 to make respective relative rotations between the third external barrel 15 and the first linear guide ring 14 and between the helicoid ring 18 and the first linear guide ring 14 possible and to be movable together along a direction of a common rotational axis (i.e., the lens barrel axis Z0) due to the engagement of the first plurality of relative rotation guide projections 14b with the circumferential groove 18g, the engagement of the second plurality of relative rotation guide projections 14c with the circumferential groove 15e and the engagement of the plurality of relative rotation guide projections 15d with the circumferential groove 14d. Rotation of the third external barrel 15 is transferred to the cam ring

11 via the set of three rotation transfer grooves 15f and the set of three roller followers 32, which are engaged in the set of three rotation transfer grooves 15f, respectively. Since the set of three roller followers 32 are also engaged in the set of three guide lots 14e, respectively, the cam ring 11 moves forward while rotating about the lens barrel axis Z0 relative to the first linear guide ring 14 in accordance with contours of the lead slot portions 14e-3 of the set of three guide lots 14e. Since the first linear guide ring 14 itself moves forward together with the third lens barrel 15 and the helicoid ring 18 as described above, the cam ring 11 moves forward in the optical axis direction by an amount of movement corresponding to the sum of the amount of the forward movement of the first linear guide ring 14 and the amount of the forward movement of the cam ring 11 by engagement of the set of three roller followers 32 with the lead slot portions 14e-3 of the set of three guide lots 14e, respectively.

【0023】

The above described rotating-advancing operations are performed while the set of three rotational sliding projections 18b are moving in the set of three lead grooves 22c, respectively, when the male helicoid 18a and the female helicoid 22a are engaged with each other.

When the helicoid ring 18 moves forward by a predetermined amount of movement, the male helicoid 18a and the female helicoid 22a are disengaged from each other so that the set of three rotational sliding projections 18b move from the set of three lead grooves 22c to the set of three rotational sliding grooves 22d, respectively, while the set of three roller followers 32 enter the front circumferential slot portions 14e-1 of the set of three guide lots 14e, respectively. Since the helicoid ring 18 does not move in the optical axis direction relative to the stationary barrel 22 even if rotating upon the disengagement of the male helicoid 18a from the female helicoid 22a, the helicoid ring 18 and the third external barrel 15 rotate at respective axial fixed positions thereof without moving in the optical axis direction. In this state, since the first linear guide ring 14 stops while the set of three roller followers 32 have respectively moved into the front circumferential slot portions 14e-1, the cam ring 11 is not given any force making the cam ring 11 move forward. Consequently, the cam ring 11 only rotates at an axial fixed position in accordance with rotation of the third external barrel 15.

【0024】

Rotating the zoom gear 28 in a lens barrel

retracting direction thereof causes the aforementioned movable elements of the zoom lens 71 from the stationary barrel 22 to the cam ring 11 to operate in the reverse manner to the above described advancing operations. In this reverse operation, the above described fundamental movable elements of the zoom lens 71 retract to their respective retracted positions shown in Figure 7 by rotation of the helicoid ring 18 until the set of three roller followers 32 enter the rear circumferential slot portions 14e-2 of the set of three guide lots 14e, respectively.

【0025】

The first linear guide ring 14 is provided on an inner peripheral surface thereof with a set of three pairs of first linear guide grooves 14f which are formed at different circumferential positions to extend parallel to the photographing optical axis Z1, and a set of six second linear guide grooves 14g which are formed at different circumferential positions to extend parallel to the photographing optical axis Z1. Each pair of first linear guide grooves 14f are position on the opposite sides of the associated linear guide groove 14g (every other linear guide groove 14g) in a circumferential direction of the first linear guide ring 14. A second linear guide ring 10 is provided on an outer

edge thereof with a set of three bifurcated projections 10a. Each bifurcated projection 10a (see Figures 3 and 15) is provided at a radially outer end thereof with a pair of radial projections which are respectively engaged in the associated pair of first linear guide grooves 14f. On the other hand, a set of six linear guide projections 13a (see Figures 2 and 17) which are formed on an outer peripheral surface of the second external barrel 13 at a rear end thereof to project radially outwards are engaged in the set of six second linear guide grooves 14g, respectively to be slidable therealong. Therefore, each of the second external barrel 13 and the second linear guide ring 10 is guided in the optical axis direction via the first linear guide ring 14.

【0026】

The second linear guide ring 10 serves as a linear guide member for guiding a second lens group moving frame 8 linearly without rotating the same, while the second external barrel 13 serves as a linear guide member for guiding the first external barrel 12 linearly without rotating the same. The second lens group moving frame 8 supports the second lens group LG2. The first external barrel 12 supports the first lens group LG1.

【0027】

The second linear guide ring 10 is provided on a ring

portion 10b thereof with a set of three linear guide keys 10c which project forward (see Figures 3 and 15) from the ring portion 10b. As shown in Figures 6 and 7, an outer edge of the ring portion 10b is engaged in a circumferential groove 11e formed on an inner peripheral surface of the cam ring 11 at the rear end thereof to be rotatable about the lens barrel axis Z0 relative to the cam ring 11 and to be immovable relative to the cam ring 11 in the optical axis direction. The set of three linear guide keys 10c project forward from the ring portion 10b to be positioned inside the cam ring 11. Opposite edges of each linear guide key 10c in a circumferential direction of the second linear guide ring 10 serve as parallel guide edges which are respectively engaged with circumferentially-opposed guide surfaces in an associated linear guide groove 8a of the second lens group moving frame 8, which is positioned in the cam ring 11 to be supported thereby, to guide the second lens group moving frame 8 linearly in the optical axis direction without rotating the same about the lens barrel axis Z0. The linear guide grooves 8a are formed on an outer peripheral surface of the second lens group moving frame 8.

【0028】

The cam ring 11 is provided on an inner peripheral

surface thereof with a plurality of inner cam grooves 11a. As shown in Figure 14, the plurality of inner cam grooves 11a are composed of a set of three front inner cam grooves 11a-1 formed at different circumferential positions, and a set of three rear inner cam grooves 11a-2 formed at different circumferential positions behind the set of three front inner cam grooves 11a-1. Although all the six cam grooves of the cam ring 11: the set of three front inner cam grooves 11a-1 and the set of three rear inner cam grooves 11a-2 trace six reference cam diagrams "α" having the same shape and size, respectively, the area of each front inner cam groove 11a-1 on the reference cam diagram thereof is partly different from the area of the associated rear inner cam groove 11a-2 on the reference cam diagram thereof. Each reference cam diagram α represents the shape of each cam groove of the set of three front inner cam grooves 11a-1 and the set of three rear inner cam grooves 11a-2, and includes a lens-barrel operating section and a lens-barrel assembling/disassembling section, wherein the lens-barrel operating section consists of a zooming section and a lens-barrel retracting section. The lens-barrel operating section serves as a control section which controls movement of the second lens group moving frame 8 with respect to the cam ring 11, and which

is to be distinguished from the lens-barrel assembling/disassembling section that is used only when the zoom lens 71 is assembled or disassembled. The zooming section serves as a control section which controls the movement of the second lens group moving frame 8 with respect to the cam ring 11, especially from a position of the second lens group moving frame 8 which corresponds to the wide-angle extremity of the zoom lens 71 to another position of the second lens group moving frame 8 which corresponds to the telephoto extremity of the zoom lens 71, and which is to be distinguished from the lens-barrel retracting section. If each front inner cam groove 11a-1 and the rear inner cam groove 11a-2 positioned therebehind in the optical axis direction are regarded as a pair, it can be said that the cam ring 11 is provided, at regular intervals in a circumferential direction of the cam ring 11, with three pairs of inner cam grooves 11a for guiding the second lens group LG2.

【0029】

The second lens group moving frame 8 is provided on an outer peripheral surface thereof with a plurality of cam followers 8b. The plurality of cam followers 8b include a set of three front cam followers 8b-1 which are formed at different circumferential positions to be respectively engaged in the set of three front inner cam

grooves 11a-1, and a set of three rear cam followers 8b-2 which are formed at different circumferential positions behind the set of three front cam followers 8b-1 to be respectively engaged in the set of three rear inner cam grooves 11a-2.

【0030】

A rotation of the cam ring 11 causes the second lens group moving frame 8 to move in the optical axis direction in a predetermined moving manner in accordance with contours of the plurality of inner cam grooves 11a since the second lens group moving frame 8 is guided linearly in the optical axis direction without rotating via the second linear guide ring 10.

【0031】

The zoom lens 71 is provided inside the second lens group moving frame 8 with a second lens frame (swingable member) 6. The second lens frame 6 is pivoted on a pivot shaft 33 front and rear ends of which are supported by front and rear second lens frame support plates 36 and 37, respectively. The pair of second lens frame support plates 36 and 37 are fixed to the second lens group moving frame 8 by a support-plate set screw 66. The pivot shaft 33 is a predetermined distance away from the photographing optical axis Z1, and extend parallel to the photographing optical axis Z1. The second lens frame 6

is swingable about the pivot shaft 33 between a photographing position shown in Figure 6 where the optical axis of the second lens group LG2 coincides with the photographing optical axis Z1 and a retracted position shown in Figure 7 where the optical axis of the second lens group LG2 is eccentric from the photographing optical axis Z1. A rotation limit pin 35 which determines the photographing position of the second lens frame 6 is mounted to the second lens group moving frame 8. The second lens frame 6 is biased to rotate in a direction to come into contact with the rotation limit pin 35 by a second-lens-frame returning spring 39. An axial-direction pressing spring 38 removes backlash of the second lens frame 6 in the optical axis direction.

【0032】

The second lens frame 6 moves together with the second lens group moving frame 8 in the optical axis direction. The CCD holder 21 is provided on a front surface thereof with a cam bar 21a which projects forward from the CCD holder 21 to be engageable with the second lens frame 6 (see Figure 4). If the second lens group moving frame 8 moves rearward in a retracting direction to approach the CCD holder 21, a cam surface formed on a front end surface of the cam bar (position control mechanism) 21a comes into contact with the second lens

frame 6 to rotate the second lens frame 6 to the retracted position. The structure retracting the second lens group LG2 will be discussed later.

【0033】

The structure supporting the first lens group LG1 will be discussed hereinafter. The second external barrel 13 is provided, on an inner peripheral surface thereof for supporting the first lens group LG1, with a set of three linear guide grooves 13b which are formed at different circumferential positions to extend in the optical axis direction. The first external barrel 12 is provided on an outer peripheral surface thereof at the rear end of the first external barrel 12 with a set of three engaging protrusions 12a which are slidably engaged in the set of three linear guide grooves 13b, respectively (see Figures 2, 17 and 18). Accordingly, the first external barrel 12 is guided linearly in the optical axis direction without rotating about the lens barrel axis Z0 via the first linear guide ring 14 and the second external barrel 13. The second external barrel 13 is further provided on an inner peripheral surface thereof in the vicinity of the rear end of the second external barrel 13 with a inner flange 13c which extends along a circumference of the second external barrel 13. The cam ring 11 is provided on an outer peripheral surface

thereof a circumferential groove 11c in which the inner flange 13c is slidably engaged so that the cam ring 11 is rotatable about the lens barrel axis Z0 relative to the second external barrel 13 and so that the second external barrel 13 is immovable in the optical axis direction relative to the cam ring 11. On the other hand, the first external barrel 12 is provided on an inner peripheral surface thereof with a set of three rollers (cam followers) 31 which projects radially inwards, while the cam ring 11 is provided on an outer peripheral surface thereof with a set of three cam grooves 11b (for guiding the first lens group LG1) in which the set of three rollers 31 are slidably engaged, respectively.

【0034】

A first lens frame 1 is supported inside the first external barrel 12 by the first external barrel 12 via a first lens group adjustment ring 2. The first lens group LG1 is supported by the first lens frame 1 to be fixed thereto. The first lens frame 1 is provided on an outer peripheral surface thereof with a male screw thread 1a, and the first lens group adjustment ring 2 is provided on an inner peripheral surface thereof with a female screw thread 2a which is engaged with the male screw thread 1a. The axis position of the first lens frame 1 relative to the first lens group adjustment ring 2 can

be adjusted via the male screw thread and the female screw thread.

【0035】

The inner flange 12c of the first external barrel 12 is provided at radially opposite positions thereon with respect to the photographing optical axis Z1 with a pair of first guide grooves 12b, respectively, while the first lens group adjustment ring 2 is provided on an outer peripheral surface thereof with a corresponding pair of guide projections 2b (only one of them appears in Figure 2) which project radially outwards in opposite directions away from each other to be slidably fitted in the pair of first guide grooves 12b, respectively. The pair of first guide grooves 12b extend parallel to the photographing optical axis Z1 so that the combination of the first lens frame 1 and the first lens group adjustment ring 2 is movable in the optical axis direction with respect to the first external barrel 12 by engagement of the pair of guide projections 2b with the pair of first guide grooves 12b. The fixing ring 3 is fixed to the first external barrel 12 by the two fixing-ring set screws 64 to close the front of the pair of guide projections 2b. The fixing ring 3 is provided at radially opposite positions thereon with respect to the photographing optical axis Z1 with a pair of spring

receiving portions 3a so that a pair of biasing springs 24 for biasing the first lens group are installed in a compressed fashion between the pair of spring receiving portions 3a and the pair of guide projections 2b, respectively. Therefore, the first lens group adjustment ring 2 is biased rearward in the optical axis direction with respect to the first external barrel 12 by the spring force of the pair of biasing springs 24. The rear limit for the axial movement of the first lens group adjustment ring 2 with respect to the fixing ring 3 is determined by engagement of a set of four engaging projections 2c of the first lens group adjustment ring 2 with a front surface (which can be seen in Figure 2) of the fixing ring 3 (see an upper half of the zoom lens in Figure 6).

【0036】

The zoom lens 71 is provided between the first and second lens groups LG1 and LG2 with a shutter unit 76 including the shutter S and the adjustable diaphragm A. The shutter unit 76 is positioned in the second lens group moving frame 8 to be supported thereby. The aerial space between the shutter S and the second lens group LG2 is fixed. Likewise, the aerial space between the diaphragm A and the second lens group LG2 is fixed. The zoom lens 71 is provided in front of the shutter unit 76 with a

shutter actuator (not shown) for driving the shutter S, and is provided behind the shutter unit 76 with a diaphragm actuator (not shown) for driving the diaphragm A. An exposure control FPC (flexible printed circuit) board 77 extends from the shutter unit 76 to establish electrical connection between the control circuit 140 and each of the shutter actuator and the diaphragm actuator.

【0037】

The zoom lens 71 is provided at the front end of the first external barrel 12 with a lens barrier mechanism which automatically closes a front end aperture of the zoom lens 71 when the zoom lens 71 is retracted into the camera body 72 to protect the photographing optical system, i.e. the first lens group LG1, from getting stains and scratches thereon when the digital camera 70 is not in use. The lens barrier mechanism is provided with a pair of barrier blades 104 and 105. The pair of barrier blades 104 and 105 are rotatable about two pivots projecting rearward therefrom to be positioned on radially opposite sides of the photographing optical axis Z1, respectively. The lens barrier mechanism is further provided with a pair of barrier blade biasing springs 106, a barrier blade drive ring 103, a drive ring biasing spring 107 and a barrier blade holding plate 102.

The pair of barrier blades 104 and 105 are biased to rotate in opposite directions to be closed by the pair of barrier blade biasing springs 106, respectively. The barrier blade drive ring 103 is rotatable about the lens barrel axis Z0, and is engaged with the pair of barrier blades 104 and 105 to open the pair of barrier blades 104 and 105 when driven to rotate in a predetermined rotational direction. The barrier blade drive ring 103 is biased to rotate in a barrier opening direction to open the pair of barrier blades 104 and 105 by the drive ring biasing spring 107. The barrier blade holding plate 102 is positioned between the barrier blade drive ring 103 and the pair of barrier blades 104 and 105. The spring force of the drive ring biasing spring 107 is greater than the spring force of the pair of barrier blade biasing springs 106 so that the barrier blade drive ring 103 is held in a specific rotational position thereof to open the pair of barrier blades 104 and 105 against the biasing force of the pair of barrier blade biasing springs 106 in the state shown in Figure 6 where the zoom lens 71 has been extended forward to a point in a zooming range (zooming operation performable range) where a zooming operation can be carried out. In the course of the retracting movement of the zoom lens 71 to the retracted position shown in Figure 10 from a position in the zooming

range, the barrier blade drive ring 103 is forcefully rotated in a barrier closing direction opposite to the aforementioned barrier opening direction by a barrier drive ring pressing surface 11d (see Figures 3 and 13) formed on the cam ring 11. This rotation of the barrier blade drive ring 103 causes the barrier blade drive ring 103 to be disengaged from the pair of barrier blades 104 and 105 so that the pair of barrier blades 104 and 105 are closed by the spring force of the pair of barrier blade biasing springs 106. The zoom lens 71 is provided immediately in front of the lens barrier mechanism with a lens barrier cover (decorative plate) 101 which covers the front of the lens barrier mechanism.

【0038】

A lens barrel advancing operation and a lens barrel retracting operation of the zoom lens 71 having the above described structure will be roughly discussed hereinafter with reference to Figures 6, 7 and 19. Figure 19 conceptually shows the relationship among fundamental elements of the zoom lens. In Figure 19, the symbols "(S)", "(L)", "(R)" and "(RL)" which are each appended as a suffix to the reference numeral of some elements of the zoom lens 71 indicate that the element is stationary, the element is solely movable linearly along a lens barrel axis Z0 without rotating about the

lens barrel axis Z0, the element is rotatable about the lens barrel axis Z0 without moving along the lens barrel axis Z0, and the element is solely movable along the lens barrel axis Z0 while rotating about the lens barrel axis Z0, respectively. Additionally, in Figure 19, each of the symbol "(R, RL)" and the symbol "(S, L) which is appended as a suffix to the reference numeral of some elements of the zoom lens 71 indicates that the operation of each of the elements changes between the advancing operation and the retracting operation.

【0039】

The stage at which the cam ring 11 is driven to advance from the retracted position to the position where the cam ring 11 rotates at the axial fixed position without moving in the optical axis direction has been discussed above, and will be briefly discussed hereinafter. In the state shown in Figure 7 in which the zoom lens 71 is in the retracted state, the zoom lens 71 is fully accommodated in the camera body 72 so that the front face of the zoom lens 71 is substantially flush with the front face of the camera body 72. Rotating the zoom gear 28 in the lens barrel advancing direction by the zoom motor 150 causes a combination of the helicoid ring 18 and the third external barrel 15 to move forward while rotating about the lens barrel axis Z0 due to engagement

of the female helicoid 22a with the male helicoid 18a, and further causes the first linear guide ring 14 to move forward together with the helicoid ring 18 and the third external barrel 15. At this time, the cam ring 11 which rotates by rotation of the third external barrel 15 moves forward in the optical axis direction by an amount of movement corresponding to the sum of the amount of the forward movement of the first linear guide ring 14 and the amount of the forward movement of the cam ring 11 by a leading structure between the cam ring 11 and the first linear guide ring 14 (by engagement of the set of three roller followers 32 with the lead slot portions 14e-3 of the set of three guide lots 14e, respectively). Once the combination of the helicoid ring 18 and the third external barrel 15 advances to a predetermined point, the male helicoid 18a is disengaged from the female helicoid 22a while the set of three roller followers 32 are disengaged from the lead slot portions 14e-3 to enter the front circumferential slot portions 14e-1, respectively. Consequently, each of the helicoid ring 18 and the third external barrel 15 rotates about the lens barrel axis Z0 without moving in the optical axis direction.

【0040】

A rotation of the cam ring 11 causes the second lens

group moving frame 8, which is positioned inside the cam ring 11, to move in the optical axis direction with respect to the cam ring 11 in a predetermined moving manner due to the engagement of the plurality of cam followers 8b with the plurality of cam grooves 11a, respectively. In the state shown in Figure 7 in which the zoom lens 71 is in the retracted state, the second lens frame 6, which is positioned inside the second lens group moving frame 8, has rotated about the pivot shaft 33 to be held in the retracted position above the photographing optical axis Z1 by the cam bar 21a so that the optical axis of the second lens group LG2 moves from the photographing optical axis Z1 to a retracted optical axis Z2 positioned above the photographing optical axis Z1. In the course of movement of the second lens group moving frame 8 from the retracted position to a position in the zooming range, the second lens frame 6 is disengaged from the cam bar 21a to rotate about the pivot shaft 33 from the retracted position to the photographing position shown in Figure 6 where the optical axis of the second lens group LG2 coincides with the photographing optical axis Z1 by the sprig force of the second-lens-frame returning spring 39. Thereafter, the second lens frame 6 remains to be held in the photographing position until when the zoom lens 71 is

retracted into the camera body.

【0041】

In addition, a rotation of the cam ring 11 causes the first external barrel 12, which is positioned around the cam ring 11 and guided linearly in the optical axis direction without rotating, to move in the optical axis direction relative to the cam ring 11 in a predetermined moving manner due to engagement of the set of three rollers 31 with the set of three cam grooves 11b, respectively.

【0042】

Accordingly, an axial position of the first lens group LG1 relative to a picture plane (a light-sensitive surface of the CCD image sensor 60) when the first lens group LG1 is moved forward from the retracted position is determined by the sum of the amount of forward movement of the cam ring 11 relative to the stationary barrel 22 and the amount of movement of the first external barrel 12 relative to the cam ring 11, while an axial position of the second lens group LG2 relative to the picture plane when the second lens group LG2 is moved forward from the retracted position is determined by the sum of the amount of forward movement of the cam ring 11 relative to the stationary barrel 22 and the amount of movement of the second lens group moving frame 8 relative to the cam ring

11. A zooming operation is carried out by moving the first and second lens groups LG1 and LG2 on the photographing optical axis Z1 while changing the space therebetween. When the zoom lens 71 is driven to advance from the retracted position shown in Figure 7, the zoom lens 71 firstly goes into a state shown below the photographing lens axis Z1 in Figure 9 in which the zoom lens 71 is set at wide-angle extremity. Subsequently, the zoom lens 71 goes into the state shown above the photographing lens axis Z1 in Figure 9 in which the zoom lens 71 is set at telephoto extremity by a further rotation of the zoom motor 150 in a lens barrel advancing direction thereof. As can be seen from Figure 9, the space between the first and second lens groups LG1 and LG2 when the zoom lens 71 is set at the wide-angle extremity is greater than that when the zoom lens 71 is set at the telephoto extremity. When the zoom lens 71 is set at the telephoto extremity as shown above the photographing lens axis Z1 in Figure 9, the first and second lens groups LG1 and LG2 have moved to approach each other to have some space therebetween which is smaller than the space in the zoom lens 71 set at the wide-angle extremity. This variation of the space between the first and second lens groups LG1 and LG2 for zooming operation is achieved by contours of the plurality of cam

grooves 11a and the set of three cam grooves 11b. In the zooming range between the wide-angle extremity and the telephoto extremity, the cam ring 11, the third external barrel 15 and the helicoid ring 18 rotate at their respective axial fixed positions, i.e., without moving in the optical axis direction.

【0043】

In the zooming range, a focusing operation is carried out by moving the third lens group LG3 (the AF lens frame 51) along the photographing optical axis Z1 by rotation of the AF motor 160 in accordance with an object distance.

【0044】

Driving the zoom motor 150 in a lens barrel retracting direction causes the zoom lens 71 to operate in the reverse fashion to the above described advancing operation to fully retract the zoom lens 71 into the camera body 72 as shown in Figure 7. In the course of this retracting movement of the zoom lens 71, the second lens frame 6 rotates about the pivot shaft 33 to the retracted position by the cam bar 21a while moving rearward together with the second lens group moving frame 8. When the zoom lens 71 is fully retracted into the camera body 72, the second lens group LG2 is retracted into the space radially outside the space in which the

third lens group LG3 and the low-pass filter LG4 are retracted as shown in Figure 10, i.e., the second lens group LG2 is into an axial range substantially identical to an axial range in the optical axis direction in which the third lens group LG3 and the low-pass filter LG4 are positioned. This structure of the camera 70 for retracting the second lens group LG2 in this manner reduces the length of the zoom lens 71 when the zoom lens 71 is fully retracted, thus making it possible to reduce the thickness of the camera body 72 in the horizontal direction as viewed in Figure 7.

【0045】

The digital camera 70 is provided with a zoom viewfinder the focal length of which varies to correspond to the focal length of the zoom lens 71. The zoom viewfinder is given a driving force from the helicoid ring 18 by engagement of a viewfinder drive gear 30 with the spur gear portion 18c of the helicoid ring 18 so that the viewfinder drive gear 30 rotates by rotation of the helicoid ring 18 when the helicoid ring 18 rotates at the aforementioned fixed position in the zooming range. The zoom viewfinder is provided with a zoom type viewing optical system including an objective window plate 81a, a movable power-varying lens 81b, a movable power-varying lens 81c, a prism 81d, an eyepiece 81e and

an eyepiece window plate 81f in this order from the object side. The focal length of the zoom viewfinder varies by moving the movable power-varying lens 81b and the movable power-varying lens 81c along an optical axis Z3 of the objective optical system of the zoom viewfinder. The optical axis Z3 is parallel to the photographing optical axis Z1. Respective support frames of the movable power-varying lens 81b and the movable power-varying lens 81c are linearly guided in a direction of the optical axis Z3 by a guide shaft 82, and each receive a drive force from a screw shaft extending parallel to the guide shaft 82. The digital camera 70 is provided between this screw shaft and the viewfinder drive gear 30 with a reduction gear train. A rotation of the viewfinder drive gear 30 causes the screw shaft to rotate to thereby move the movable power-varying lens 81b and the movable power-varying lens 81c forward and rearward. The above described elements of the zoom viewfinder are put together to be prepared as a viewfinder unit (subassembly) 80 which is mounted on top of the stationary barrel 22.

【0046】

[DESCRIPTION OF FEATURES OF THE PRESENT INVENTION]

As shown in Figures 6, 7 and 20, in the present embodiment of the zoom lens 71, the AF lens frame 51 is

made of an opaque material, and is provided with a bowl-shaped portion 51c, a first arm portion 51d, a second arm portion 51e, and guide holes 51a and 52b.

【0047】

The bowl-shaped portion 51c is formed in a box shape including a substantially square-shaped front end surface 51c1 and four side surfaces 51c3, 51c4, 51c5 and 51c6. The front end surface 51c1 lies in a plane orthogonal to the photographing optical axis Z1. The four side surfaces 51c3, 51c4, 51c5 and 51c6 extend in a direction substantially parallel to the photographing optical axis Z1, toward the CCD image sensor 60, from the four sides of the front end surface 51c1. The bowl-shaped portion 51c is provided on the front end surface 51c1 thereof with a circular opening 51c2 the center of which is coincident with the photographing optical axis Z1. The third lens group LG3 is positioned inside the circular opening 51c2.

【0048】

The first arm portion 51d and the second arm portion 51e extend from the bowl-shaped portion 51c radially in opposite directions away from each other. More specifically, the first arm portion 51d extends from a corner of the bowl-shaped portion 51c between the two side surfaces 51c3 and 51c6 radially in a lower-rightward

direction as viewed from front of the AF lens frame 51, while the second arm portion 51e extends from another corner of the bowl-shaped portion 51c between the two side surfaces 51c4 and 51c5 radially in a upper-leftward direction as viewed from front of the AF lens frame 51. The first arm portion 51d is fixed to the rear end of the corner of the bowl-shaped portion 51c between the two side surfaces 51c3 and 51c6 while the second arm portion 51e is fixed to the rear end of the corner of the bowl-shaped portion 51c between the two side surfaces 51c4 and 51c5.

【0049】

With such structure, as shown in Figures 6 and 7, since the AF lens frame 51 covers the low-pass filter LG4, the filter holder 73 and the CCD image sensor 60, superfluous light is prevented from being incident on the low-pass filter LG4 and the CCD image sensor 60 through any part other than the third lens group LG3. In addition, since the lower-pass filter LG4, the film holder 73 and CCD image sensor 60 can be accommodated in the AF lens frame 51 when the lens barrel is retracted to its retracted position, the zoom lens 71 can be retracted more deeply.

【0050】

The guide holes 51a and 51b in which the pair of AF

guide shafts 52 and 53 are respectively fitted so that the AF lens frame 51 is slidable on the pair of AF guide shafts 52 and 53 are formed on the first arm portion 51d and the second arm portion 51e, respectively. Accordingly, the AF guide shaft 52, which serves as a main guide shaft for guiding the AF lens frame 51 in the optical axis direction, is positioned outside a cylindrical wall 22f of the stationary barrel 22, while the AF guide shaft 53, which serves as an auxiliary guide shaft for secondarily guiding the AF lens frame 51 in the optical axis direction is also positioned outside the cylindrical wall 22f. The AF guide shafts 52 and 53 are positioned to face each other on opposite sides of the photographing optical axis Z1 (at positions interfering with the above movable lens group).

【0051】

Positioning the guide holes 51a and 51b in the above described manner makes it possible to retract the zoom lens 71 more deeply since any of the AF guide shafts 52, 53, the first lens group LG1 does not become an obstacle to the first lens group LG1, the second lens group LG2, third lens group LG3 and the fourth lens group LG4 when the zoom lens retracts to its retracted position. Additionally, providing on an outer peripheral part of the stationary barrel 22 with the guide holes 51 and 51e

makes it possible to secure the space having a sufficient length for guiding the AF lens frame 51 since movement of the AF lens frame 51 is not limited by any elements positioned inside the stationary barrel 22.

【0052】

The present invention can be applied not only to a zoom lens such as the above described zoom lens but also a fixed-focal-length lens.

【0053】

Although the present invention has been discussed with reference to the above described particular embodiment, obvious changes may be made in the specific embodiment described herein, such modifications being within the spirit and scope of the invention claimed. It is indicated that all matter contained herein is illustrative and does not limit the scope of the present invention.

【0054】

【Effects of the Invention】

As can be understood from the foregoing, according to the present invention, a lens barrel having a structure guiding an AF lens frame, wherein the structure does not become an obstacle to a reduction of the length of the lens barrel to thereby make it possible to improve the utilization of the camera's internal space for

accommodating elements of the camera, and wherein the space having a sufficient length for guiding the AF lens frame can be secured, is achieved.

【BRIEF DESCRIPTION OF THE DRAWING】

Figure 1 is an exploded perspective view of an embodiment of a zoom lens to which an advancing cam mechanism according to the present invention is applied;

Figure 2 is an exploded perspective view of a structure supporting a first lens group of the zoom lens;

Figure 3 is an exploded perspective view of a structure supporting a second lens group of the zoom lens;

Figure 4 is an exploded perspective view of a barrel-advancing structure from a stationary barrel to a cam ring;

Figure 5 is a perspective view of the zoom lens shown in Figure 1, showing a completed state thereof to which a zoom motor and a viewfinder unit are fixed;

Figure 6 is a longitudinal cross sectional view of a camera incorporating the zoom lens shown in Figure 1, showing a state of the zoom lens at telephoto extremity and a state of the zoom lens at wide-angle extremity;

Figure 7 is a longitudinal cross sectional view of the camera shown in Figure 6 in the retracted state of the zoom lens;

Figure 8 is a plan view of the stationary barrel;

Figure 9 is a plan view of a helicoid ring;

Figure 10 is a plan view of the helicoid ring, showing a structure of the inner peripheral surface thereof by broken lines;

Figure 11 is a plan view of a third external barrel;

Figure 12 is a plan view of a linear guide ring;

Figure 13 is a plan view of the cam ring;

Figure 14 is a plan view of the cam ring, showing a structure of the inner peripheral surface thereof by broken lines;

Figure 15 is a plan view of a second linear guide ring;

Figure 16 is a plan view of a second lens group moving frame;

Figure 17 is a plan view of a second external barrel;

Figure 18 is a plan view of a first external barrel;

Figure 19 is a conceptual diagram of elements of the zoom lens, showing the relationship among these elements;

Figure 20(a) is a perspective view showing a state where the AF lens frame is fixed to the CCD holder; and

Figure 20(b) is a plan view showing the same state as that of Figure 20(a).

【DESCRIPTIONS OF THE NUMERALS】

LG1 first lens group (movable lens group/ frontmost optical element)

LG2 second lens group (movable lens group/ front optical element)

LG3 third lens group (rearmost lens group/ middle optical element)

LG4 low-pass filter (rear optical element)

S shutter

A diaphragm

Z0 lens barrel axis

Z1 photographing optical axis

Z2 optical axis of the second lens group

Z3 optical axis of an objective optical system of a viewfinder

1 first lens frame

1a male screw thread for adjustment

2 first lens group adjustment ring

2a female screw thread

2b guide projections

2c engaging projections

3 fixing ring

3a spring receiving portions

6 second lens frame

8 second lens group moving frame

8a linear guide groove

8b cam followers for the second lens group

8b-1 front cam followers

8b-2 rear cam followers

10 second linear guide ring

10a bifurcated projections

10b ring portion

10c 10c-W linear guide keys

10d FPC-passing through hole

11 cam ring

11a cam grooves for guiding the second lens group

11a-1 front cam grooves

11a-2 rear cam grooves

11b cam grooves for guiding the first lens group

11c 11e circumferential grooves

11d barrier drive ring pressing surface

12 first external barrel

12a engaging protrusions

12b first guide grooves for adjustment of the first lens group

13 second external barrel

13a linear guide projections

13b linear guide grooves

13c inner flange

14 linear guide ring

14a linear guide projections

14b 14c relative rotation guide projections

14d circumferential groove

14e guide slots

14e-1 14e-2 circumferential slot portions

14e-3 lead slot portion

14f first linear guide grooves

14g second linear guide grooves

15 third external barrel

15a rotation transfer projections

15b engaging projections

15c spring-engaging recesses

15d relative rotation guide projections

15e circumferential groove

15f rotation transfer grooves

17 roller-biasing spring

17a roller pressing protrusions

18 helicoid ring (rotating ring)

18a male helicoid

18b rotational sliding projections (rotational sliding guide projections)

18b-A 18b-B side sliding surfaces

18b-C front sliding surface

18b-D rear sliding surface

18b-E stop-engaging surface

18c spur gear portion

18d rotation transfer recesses

18e engaging recesses

18f spring insertion recesses

18g circumferential groove

21 CCD holder

21a cam bar

22 stationary barrel (support ring)

22a female helicoid

22b linear guide grooves

22c lead grooves

22c-A 22c-B rotation-advancing surfaces

22d rotational sliding grooves (circumferential grooves)

22d-A 22d-B rotation guide surfaces

22e stop-member insertion hole

22f cylindrical portion

24 biasing springs for biasing the first lens group

25 separating-direction biasing springs

26 barrel stop member

28 zoom gear (drive gear)

29 zoom gear shaft

30 viewfinder drive gear

31 rollers for the first lens group (cam followers)

32 roller followers of the cam ring (cam followers)

32a roller set screws

33 pivot shaft for the second lens group

35 rotation limit shaft

36 37 second lens frame support plates

38 axial-direction pressing spring

39 second-lens-frame returning spring

51 AF lens frame (third lens frame)

51a 51b guide holes

51c bowl-shaped portion

51d 51e guide arm portions

52 53 AF guide shafts

54 AF nut

55 AF-frame biasing spring

60 solid-state image pick-up device (CCD/ rear optical element)

61 sealing member

62 CCD base plate

64 fixing-ring set screws

66 support-plate set screw

70 digital camera

71 zoom lens

72 camera body

73 filter holder

74 reduction gear train box

75 lens-drive-control FPC board

76 shutter unit

77 exposure control FPC board

80 viewfinder unit

81a objective window plate

81b 81c movable power-varying lenses

81d prism

81e eyepiece

81f eyepiece window plate

82 guide shaft

101 lens barrier cover

102 barrier blade holding plate

103 barrier blade drive ring

104 105 barrier blades

106 barrier blade biasing springs

107 drive ring biasing spring

150 zoom motor

160 AF motor

【TITLE OF THE DOCUMENT】 ABSTRACT

【ABSTRACT】

【SUBJECT】

A subject of the present invention is to provide a lens barrel having a structure guiding an AF lens frame, wherein the structure does not become an obstacle to a reduction of the length of the lens barrel to thereby make it possible to improve the utilization of the camera's internal space for accommodating elements of the camera, and wherein the space having a sufficient length for guiding the AF lens frame can be secured.

【PROBLEM-SOLVING MEANS】

Disclosed is a lens barrel including: a support ring; a movable lens group positioned inside the support ring, and moving forward and rearward in an optical axis direction; and a rearmost lens group positioned behind the movable lens group, and movable in the optical axis direction, wherein an arm portion is formed on a lens frame of the rearmost lens group to project in a radial direction of the lens frame, and wherein the lens barrel further comprises a guide shaft positioned outside a ring portion of the support ring to guide the rearmost lens group in the optical axis direction via the arm portion.

【SELECTED FIGURE】 Figure 20

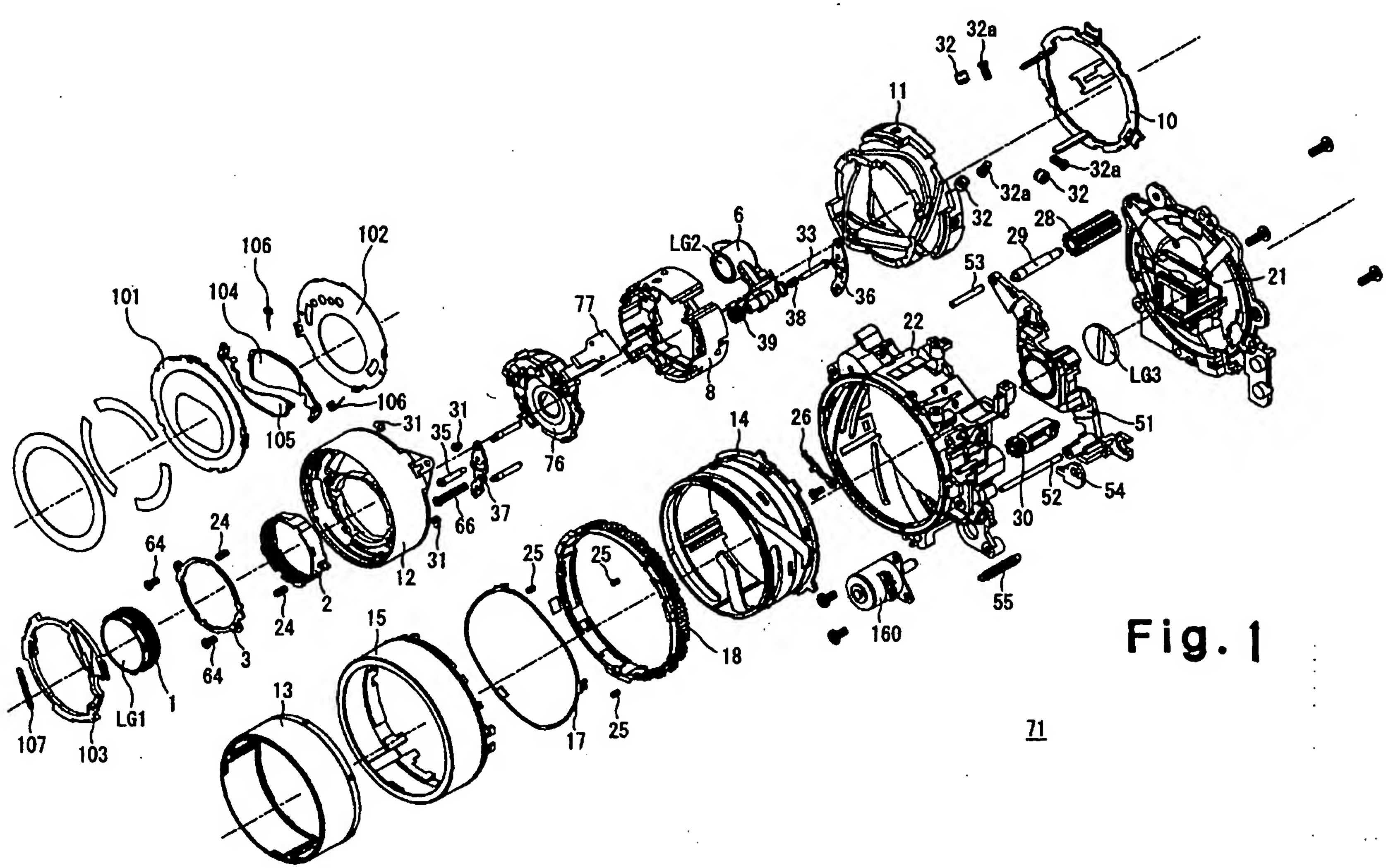

1
2
3
6
8
10
11
12
13
14
15
17
18
21
22
24
25
26
28
29
30
31
32
32a
33
35
36
37
38
39
51
52
53
54
55
64
66
76
77
101
102
103
104
105
106
107
160
LG1
LG2
LG3

Fig. 1

71

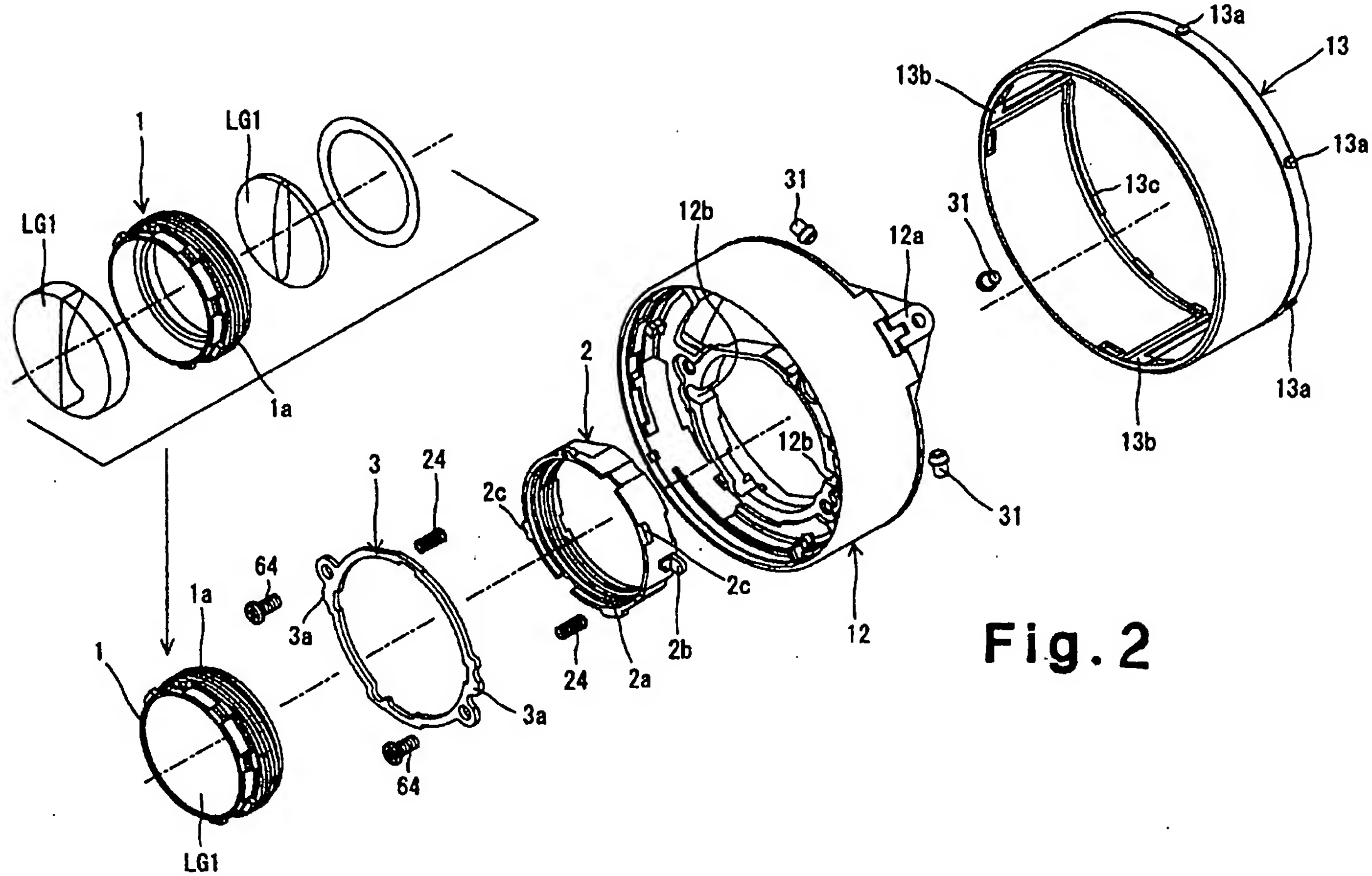
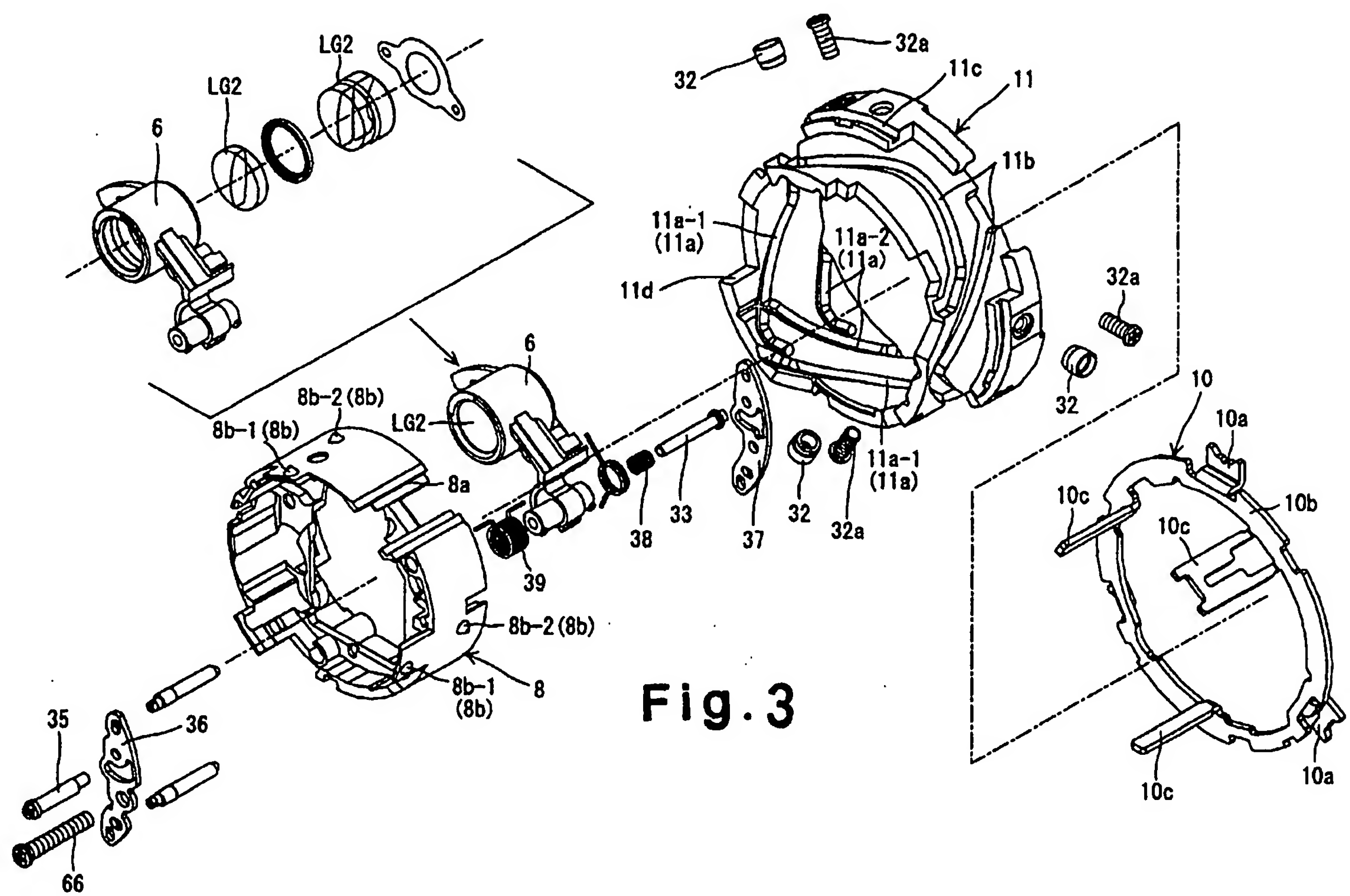

1
LG1
LG1
1a
1
1a
LG1
64
64
3a
3
3a
24
24
2c
2
2a
2b
2c
12b
12b
31
12a
31
12
31
13b
13c
13b
13a
13
13a
13a

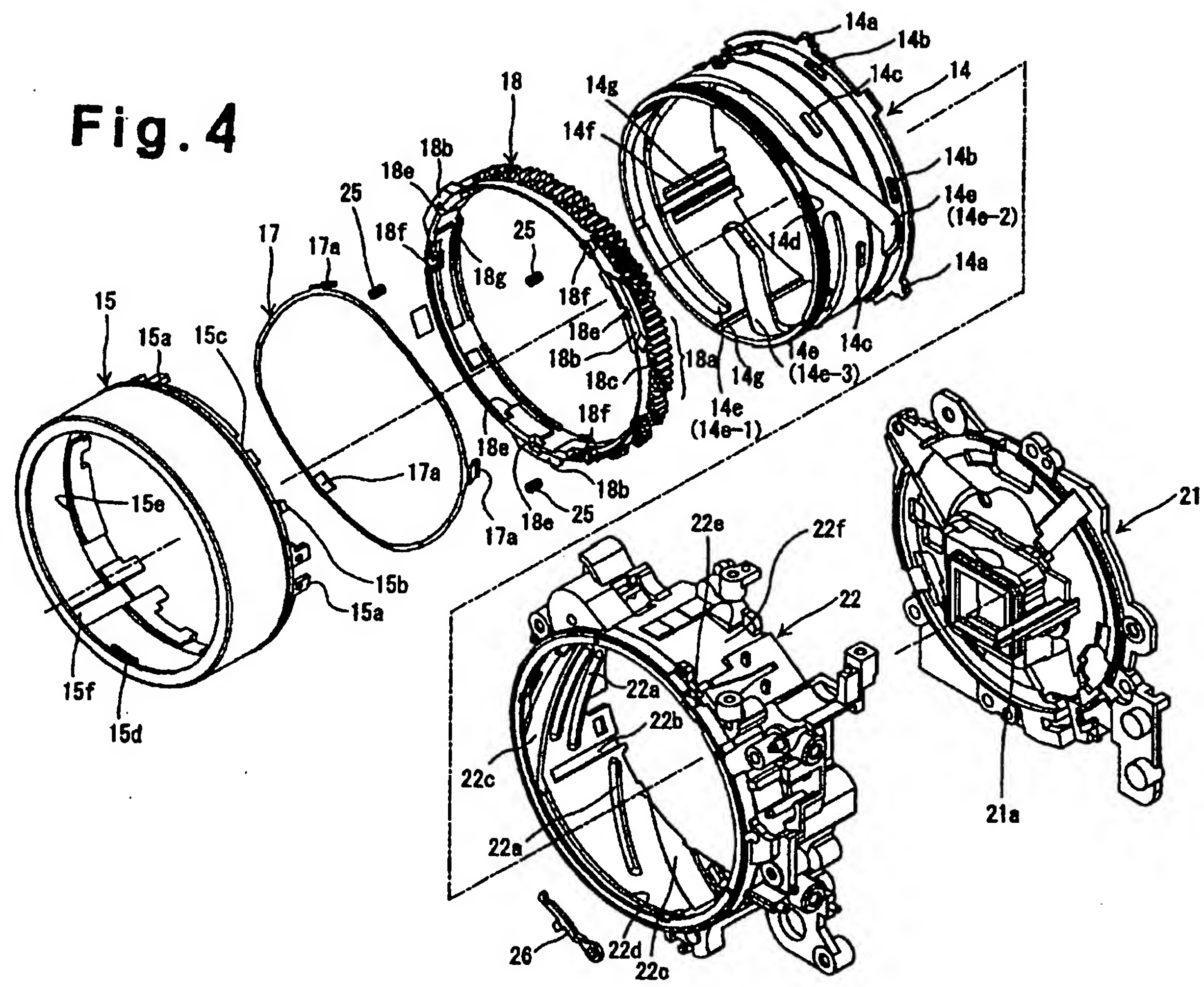
Fig.2



32a
32
11c
11
11b
11a-1
(11a)
11a-2
(11a)
11d
32a
32
10
10a
10b
10c
10c
10c
10a
LG2
LG2
6
6
LG2
8b-2 (8b)
8b-1 (8b)
8a
39
8b-2 (8b)
8b-1
(8b)
8
38
33
37
32
32a
11a-1
(11a)
35
36
66

Fig. 3

Fig. 4



14
14a
14b
14c
14d
14e
(14e-1)
(14e-2)
(14e-3)
14f
14g
15
15a
15b
15c
15d
15e
15f
17
17a
18
18a
18b
18c
18e
18f
18g
21
21a
22
22a
22b
22c
22d
22e
22f
25
26

Fig.5

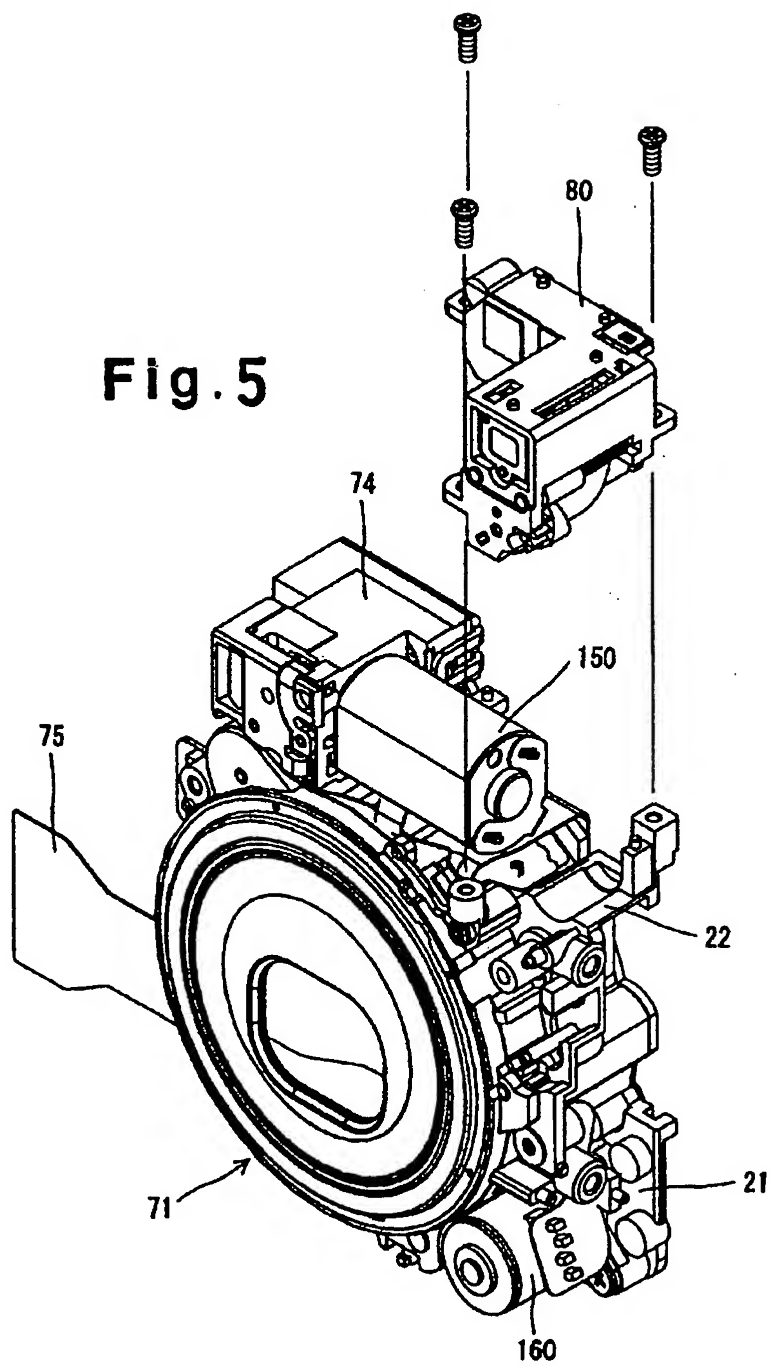
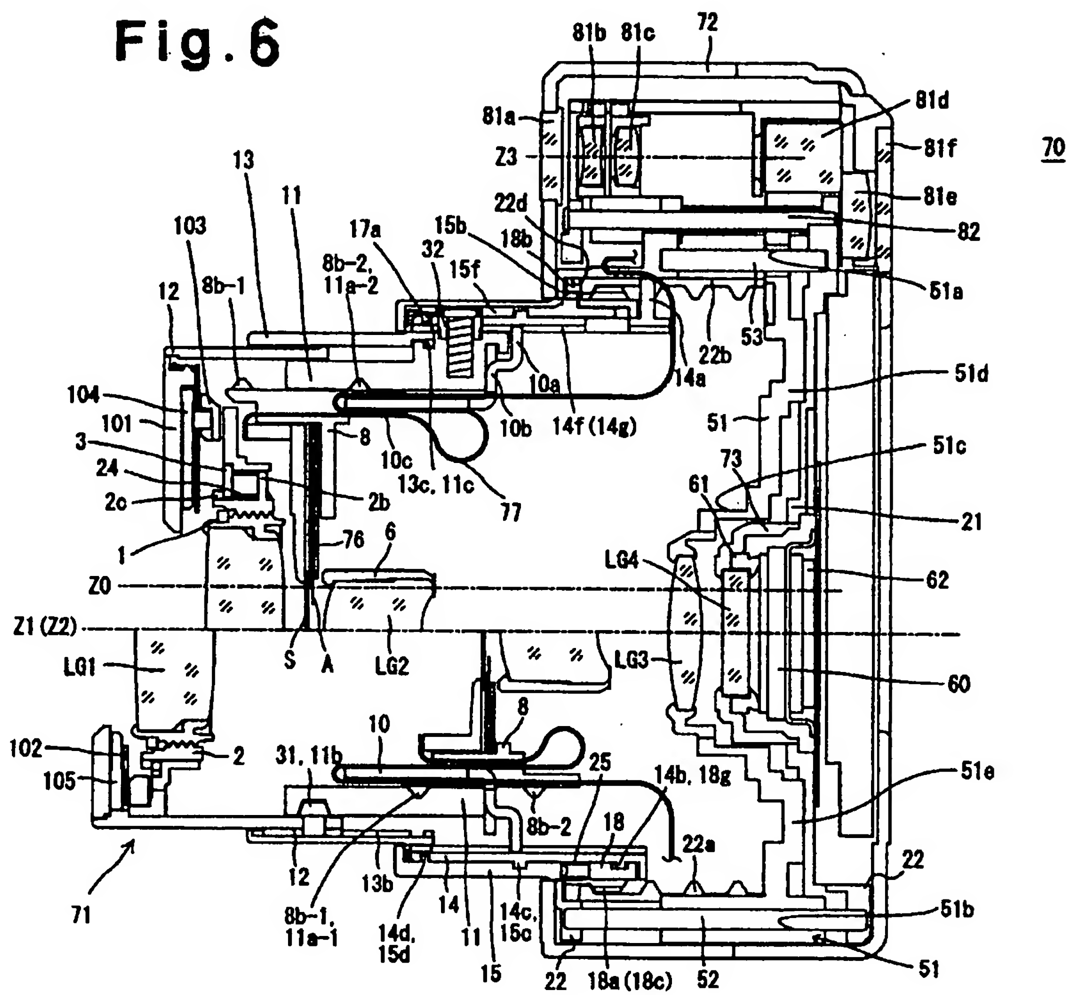
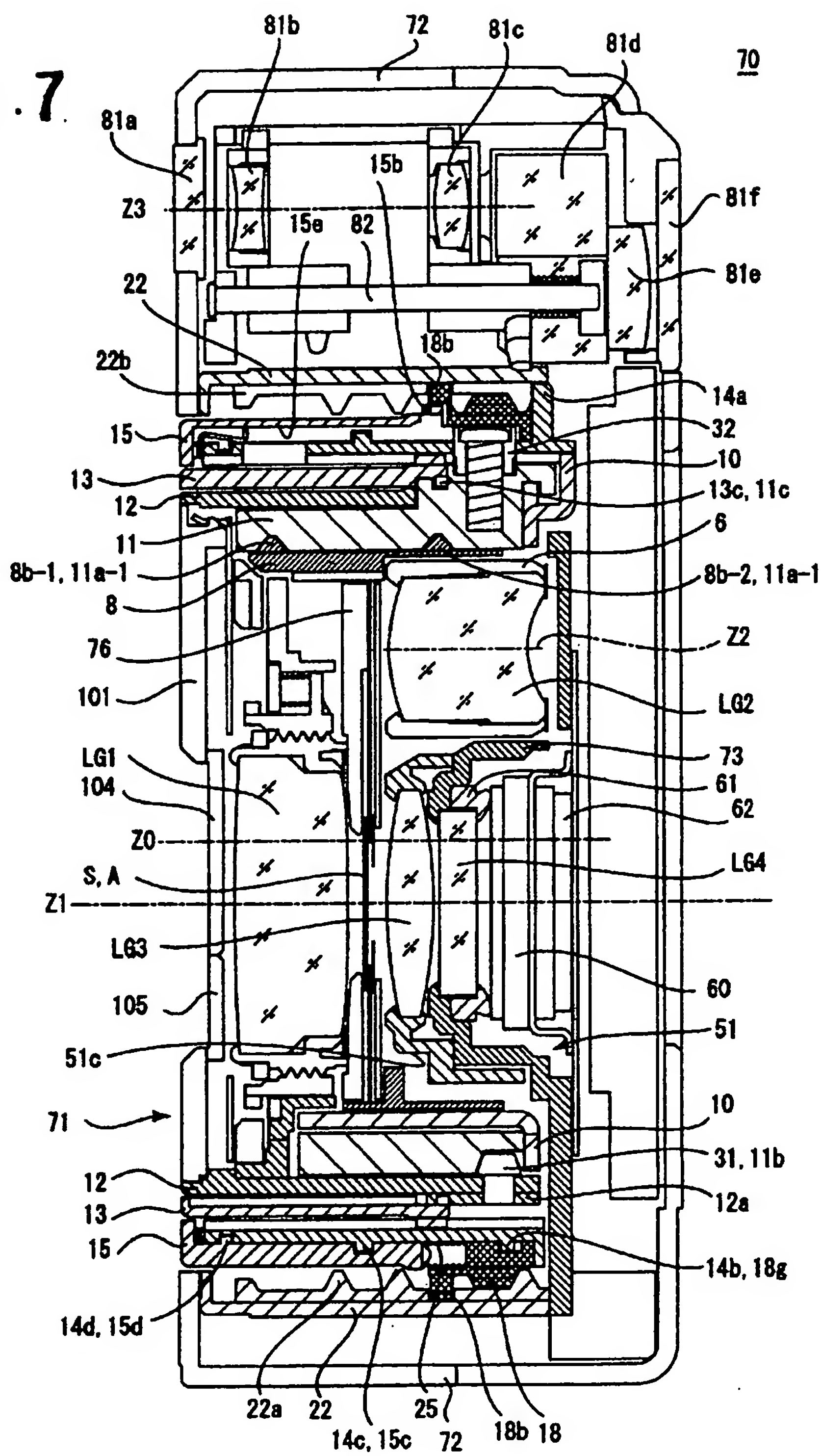


Fig.6



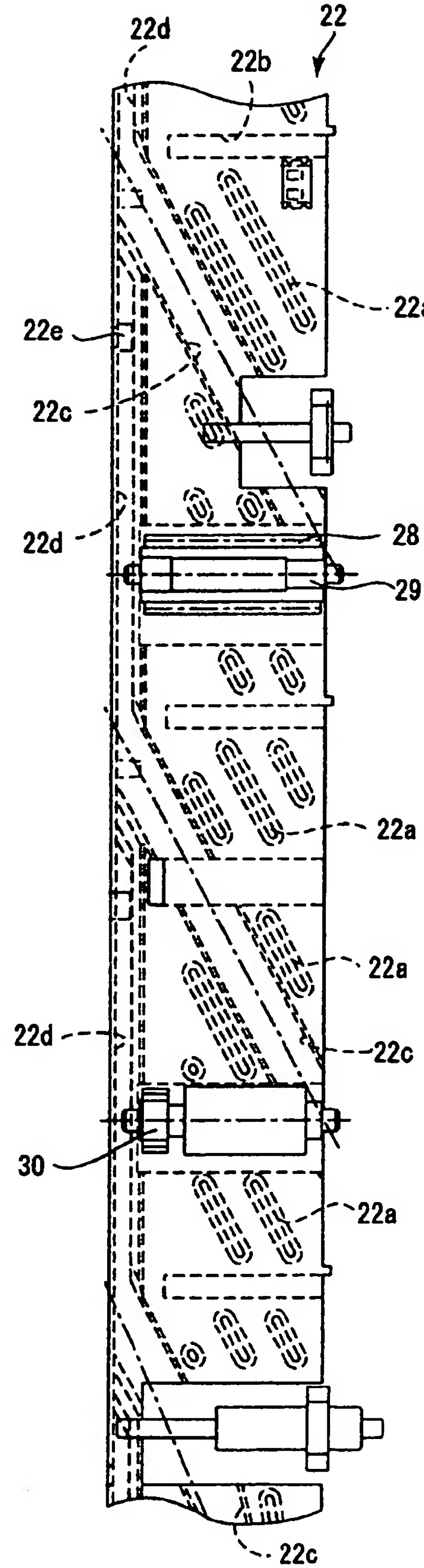
70
72
81b
81c
81a
81d
81f
Z3
81e
82
22d
18b
15b
17a
32
15f
51a
8b-2,
11a-2
103
13
11
12
8b-1
53
22b
14a
10a
51d
104
101
3
24
2c
1
8
10c
13c, 11c
77
10b
14f (14g)
51
2b
51c
73
61
21
76
6
LG4
62
Z0
Z1 (Z2)
S
A
LG2
LG1
LG3
60
102
105
2
10
8
31, 11b
25
14b, 18g
51e
18
8b-2
22a
22
71
12
13b
8b-1,
11a-1
14d,
15d
14
11
15
14c,
15c
22
18a (18c)
52
51b
51

Fig.7



81b
72
81c
81d
70
81a
15b
Z3
81f
15e
82
22
81e
22b
18b
14a
15
32
13
10
12
13c, 11c
11
6
8b-1, 11a-1
8b-2, 11a-1
8
76
Z2
101
LG2
73
LG1
61
104
62
Z0
S, A
LG4
Z1
LG3
60
105
51
51c
10
71
31, 11b
12
12a
13
15
14b, 18g
14d, 15d
22a
22
25
18b
18
14c, 15c
72

Fig. 8



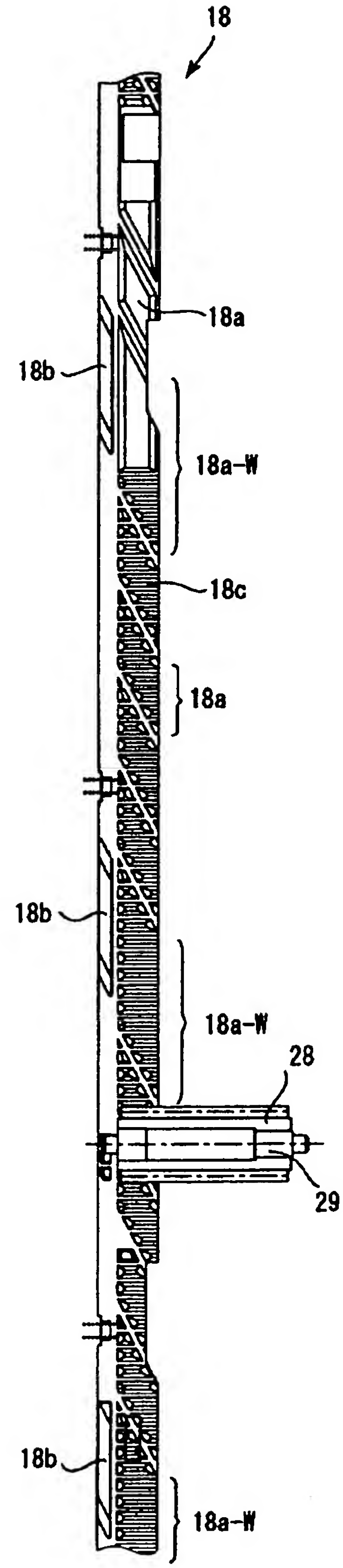


Fig.9

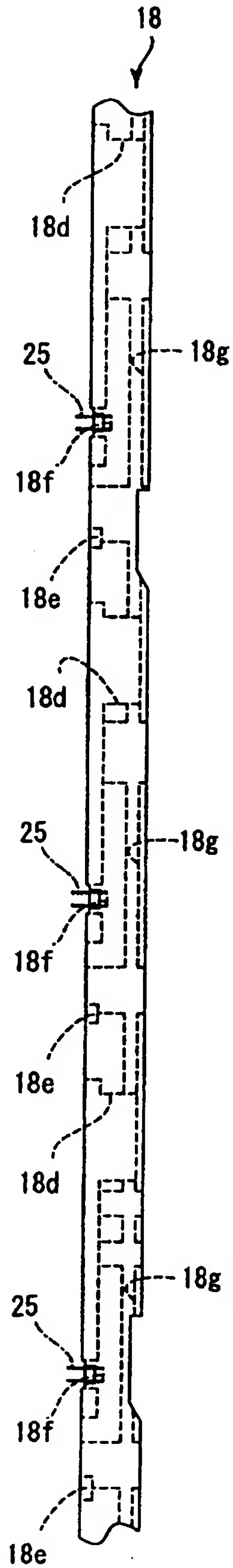


Fig.10

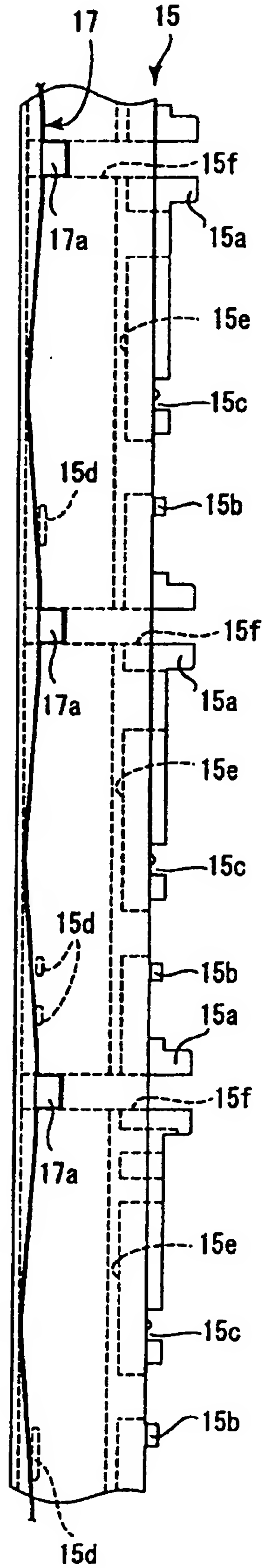
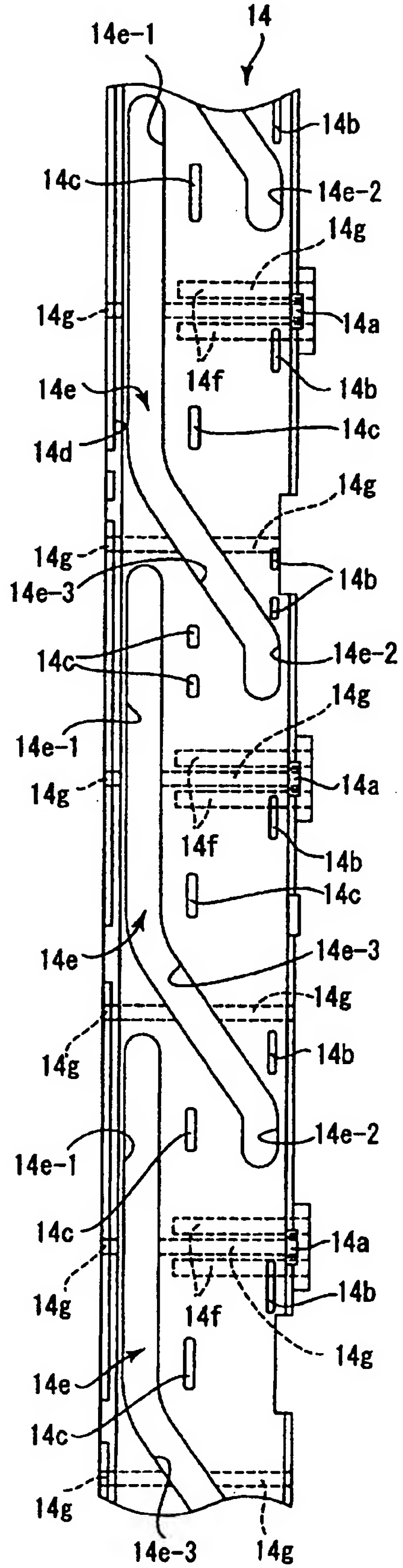

17
15
15f
17a
15a
15e
15c
15d
15b
15f
17a
15a
15e
15c
15d
15b
15a
15f
17a
15e
15c
15b
15d

Fig.11



14
14e-1
14b
14c
14e-2
14g
14g
14a
14f
14b
14e
14d
14c
14g
14g
14e-3
14b
14c
14e-2
14g
14e-1
14g
14a
14f
14b
14c
14e
14e-3
14g
14g
14b
14e-2
14e-1
14c
14a
14g
14b
14f
14g
14e
14c
14g
14e-3
14g

Fig.12

Fig.13

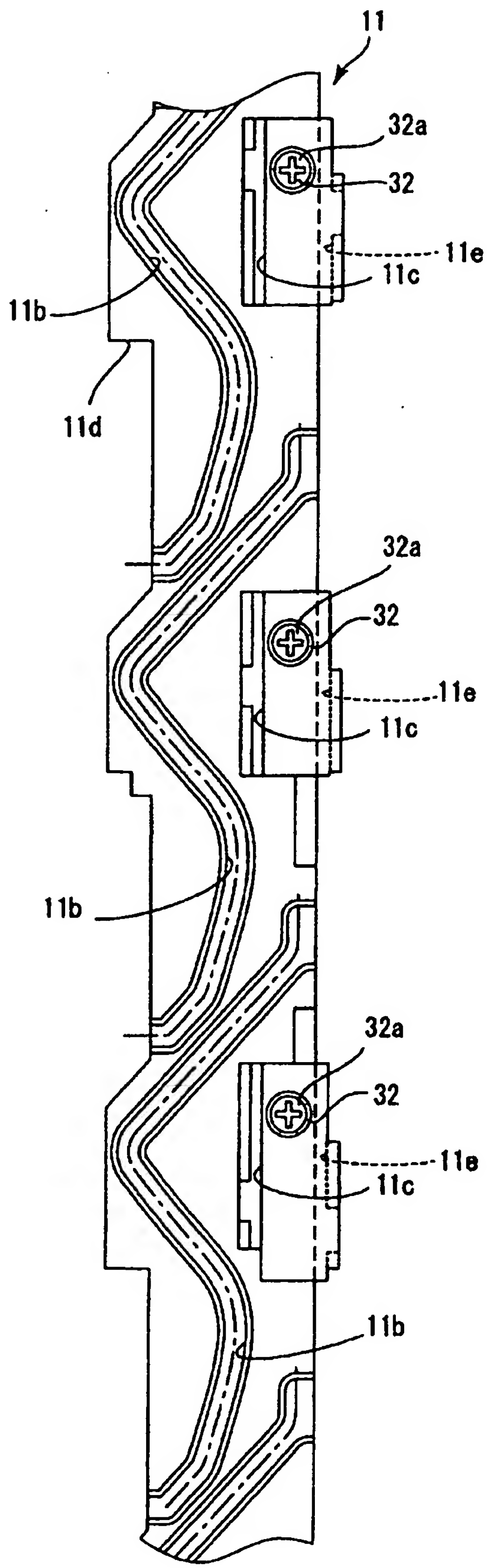


Fig.14

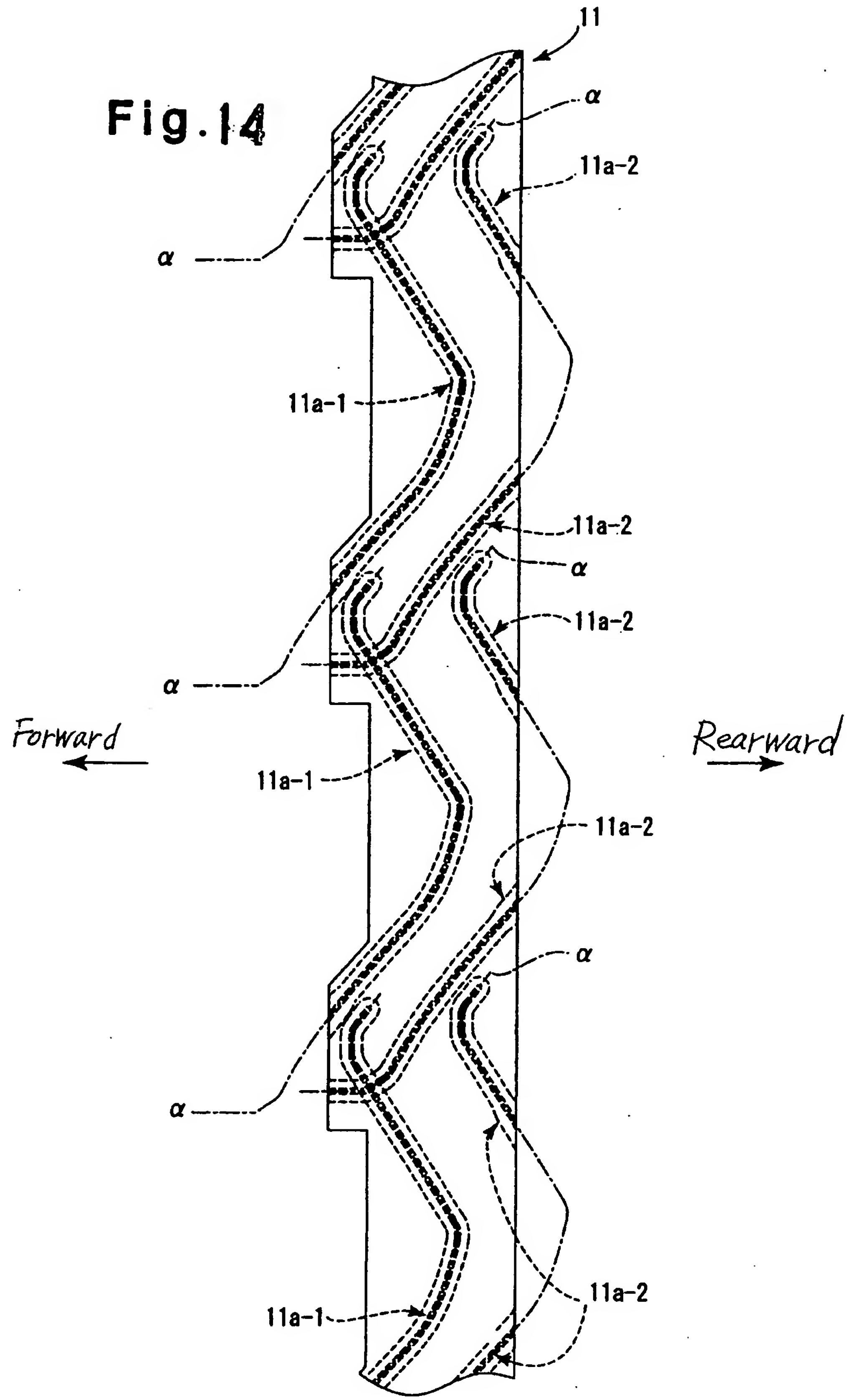

11
α
11a-2
α
11a-1
11a-2
α
11a-2
α
Forward
Rearward
11a-1
11a-2
α
α
11a-1
11a-2

Fig.15

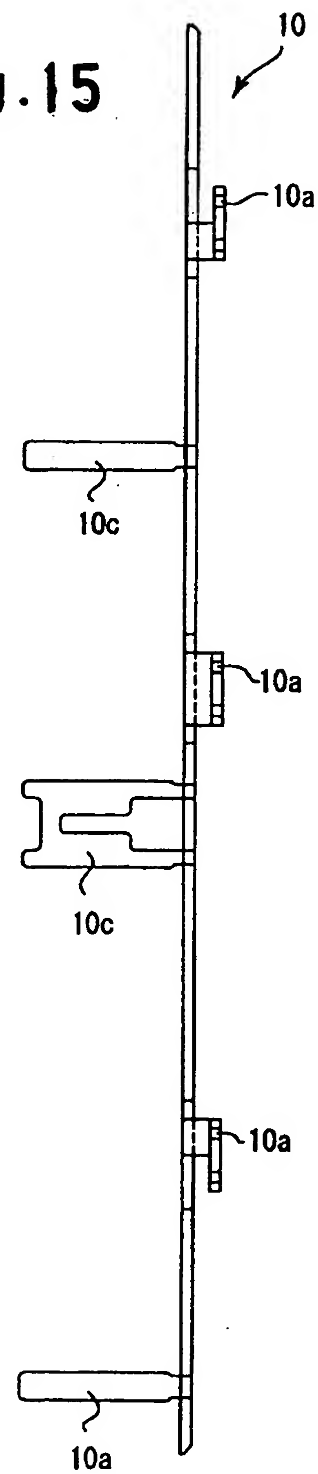


Fig.16

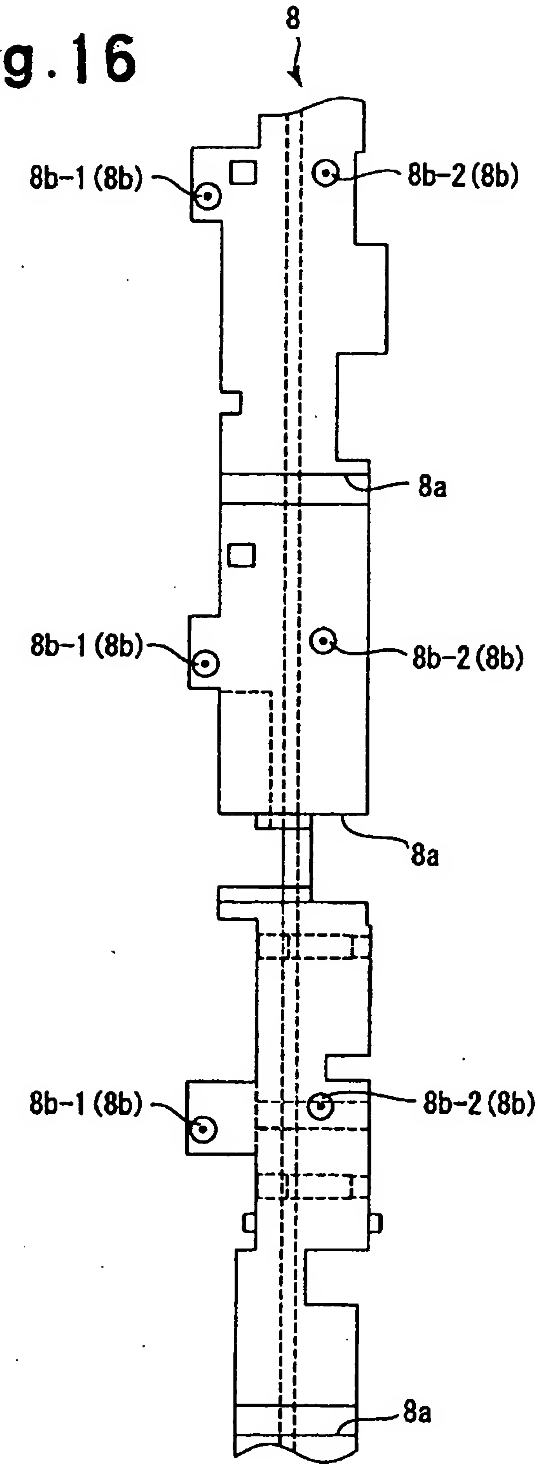


Fig. 17

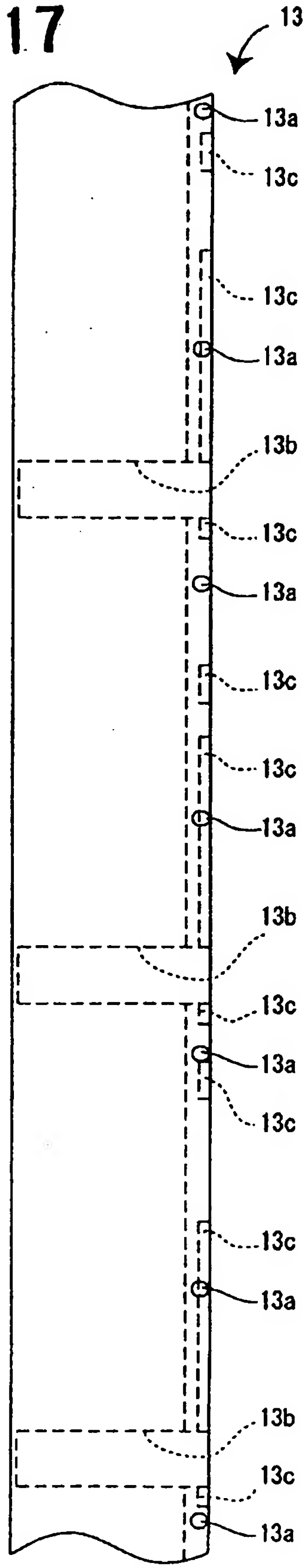

13
13a
13c
13c
13a
13b
13c
13a
13c
13c
13a
13b
13c
13a
13c
13c
13a
13b
13c
13a

Fig.18

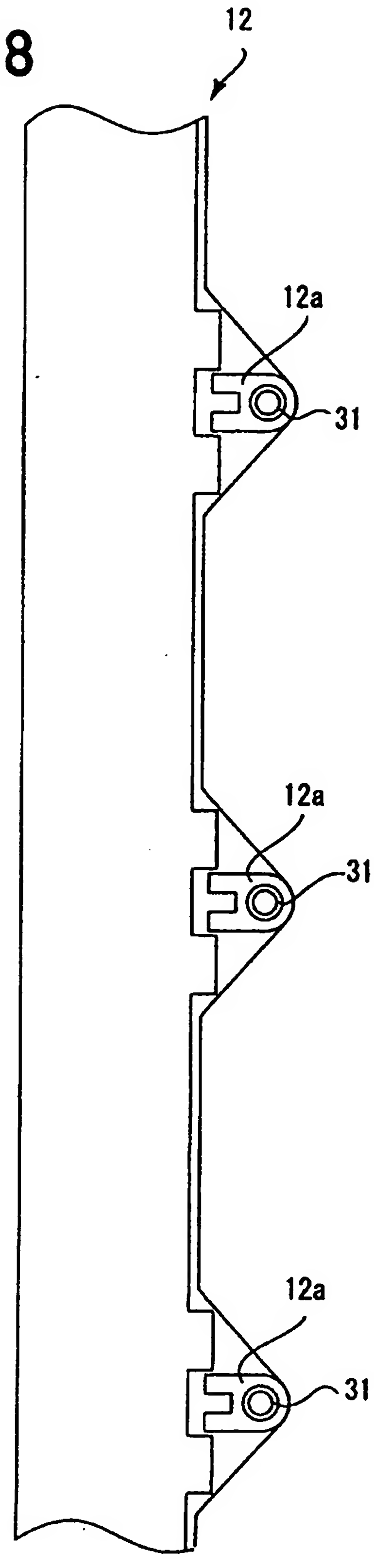


Fig. 19

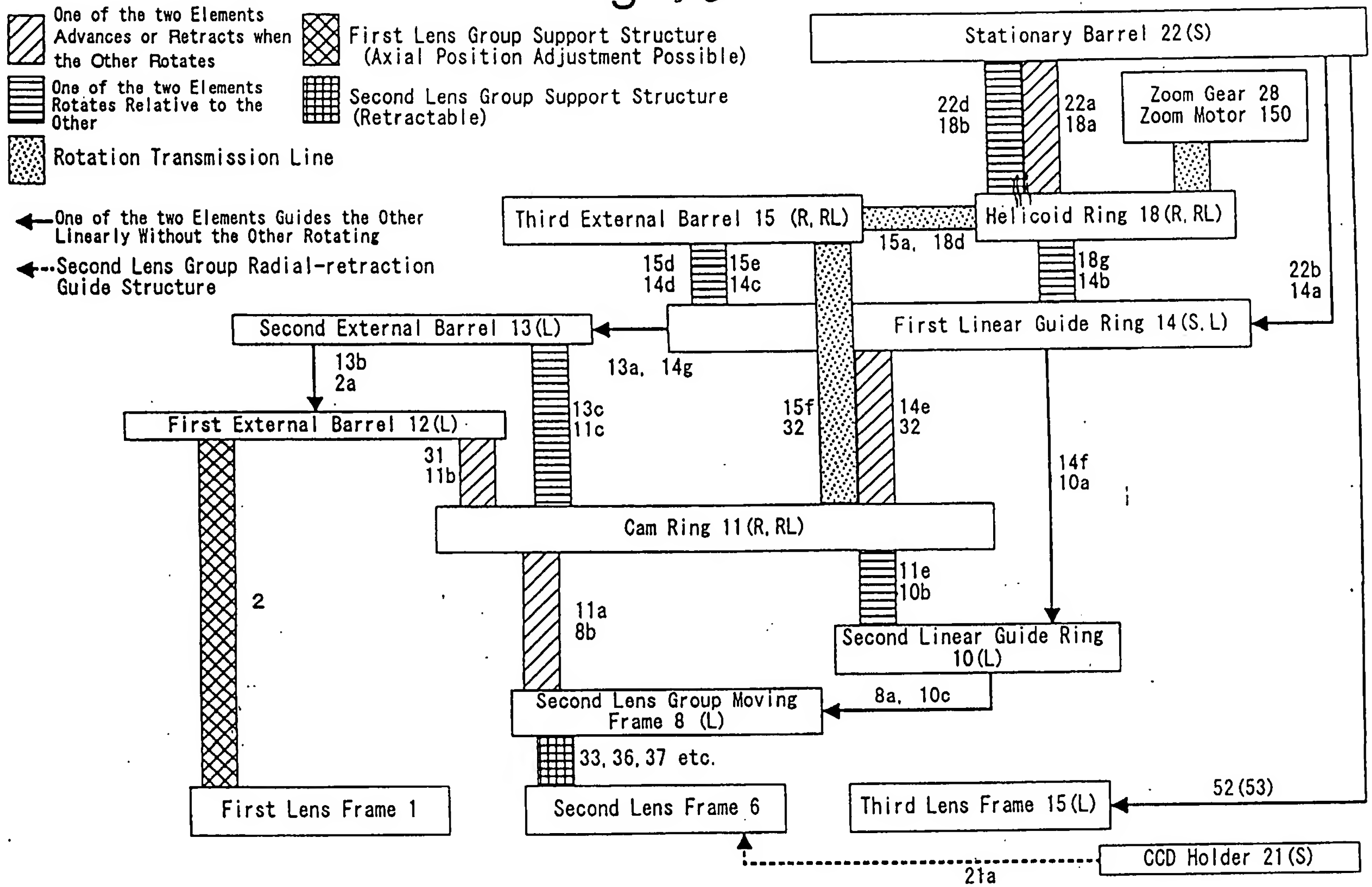

One of the two Elements Advances or Retracts when the Other Rotates
One of the two Elements Rotates Relative to the Other
Rotation Transmission Line
First Lens Group Support Structure (Axial Position Adjustment Possible)
Second Lens Group Support Structure (Retractable)
One of the two Elements Guides the Other Linearly Without the Other Rotating
Second Lens Group Radial-retraction Guide Structure
Stationary Barrel 22 (S)
Zoom Gear 28
Zoom Motor 150
22d
18b
22a
18a
Third External Barrel 15 (R, RL)
Helicoid Ring 18 (R, RL)
15a, 18d
15d
14d
15e
14c
18g
14b
22b
14a
Second External Barrel 13 (L)
First Linear Guide Ring 14 (S, L)
13b
2a
13a, 14g
First External Barrel 12 (L)
13c
11c
15f
32
14e
32
31
11b
14f
10a
Cam Ring 11 (R, RL)
2
11e
10b
11a
8b
Second Linear Guide Ring 10 (L)
Second Lens Group Moving Frame 8 (L)
8a, 10c
33, 36, 37 etc.
First Lens Frame 1
Second Lens Frame 6
Third Lens Frame 15 (L)
52 (53)
CCD Holder 21 (S)
21a

Fig.20 (a)

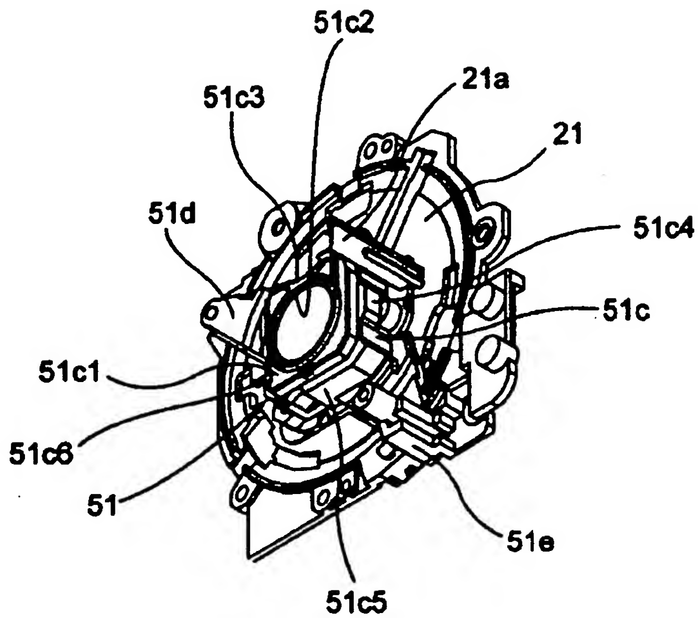


Fig.20 (b)